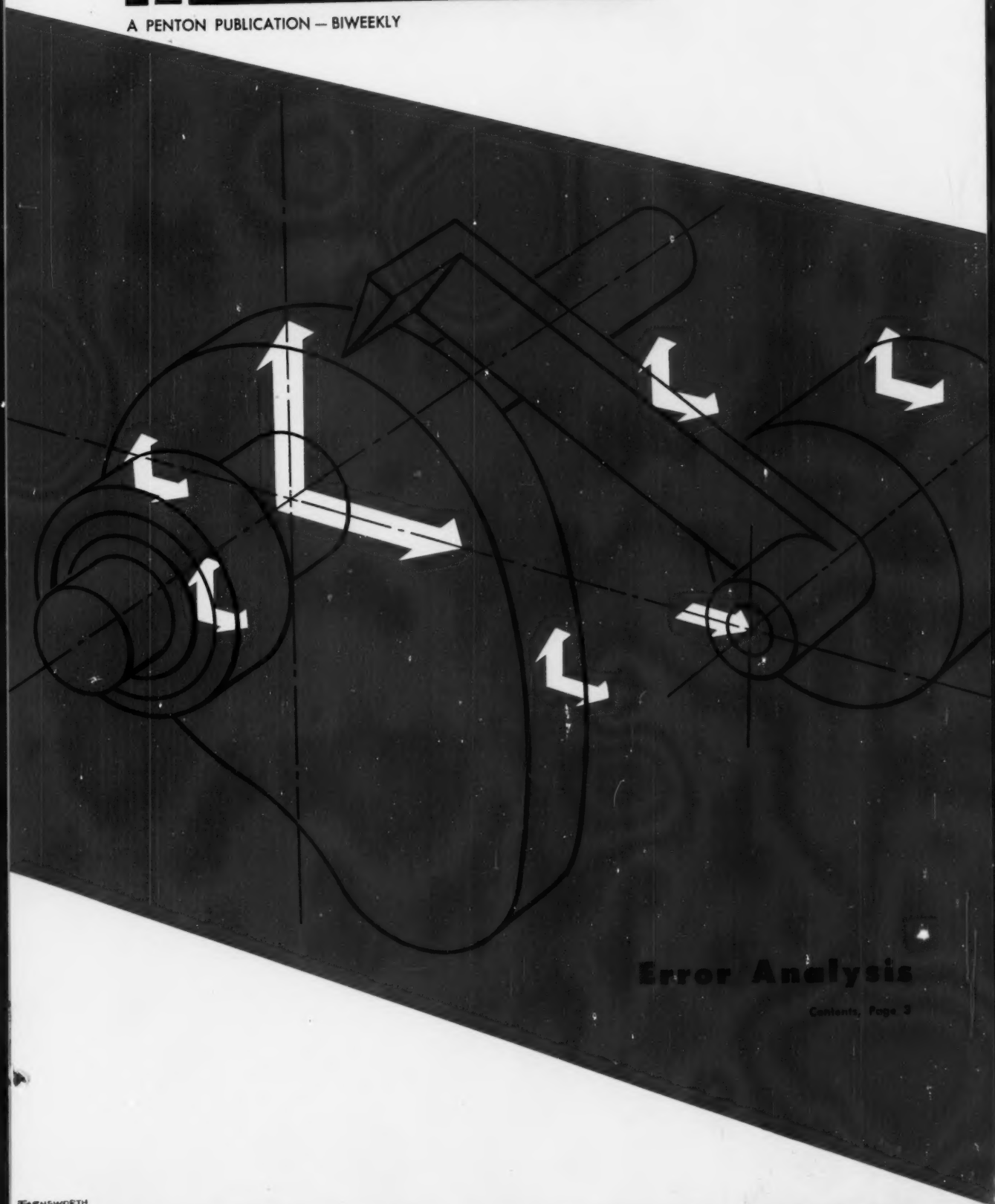
JUNE 9, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Error Analysis

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FARNSWORTH

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Choose from thousands of different shapes, sizes, attitudes, mountings, horsepowers, enclosures, ungeared or geared combinations—choose the U.S. VARIDRIVE MOTOR that exactly fits your application! U.S. introduced the *first* self-contained a.c. motorized variable speed drive for industry—in 1932! Ever since, U.S. design engineers have been developing new Varidrives to combine new characteristics... new controls, too: Manual, mechanical, electrical remote control, and automatic control. Ratings available: **¼ to 75 h.p.** *(Send for free 16-page color Varidrive Bulletin, No. F-1797.)* For your variable speed application, specify:

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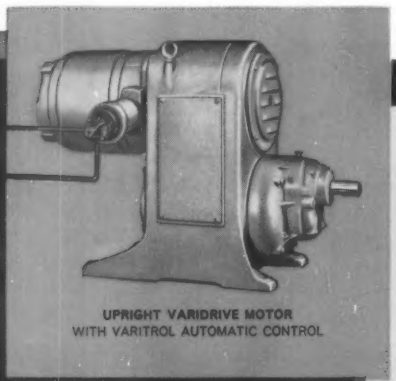
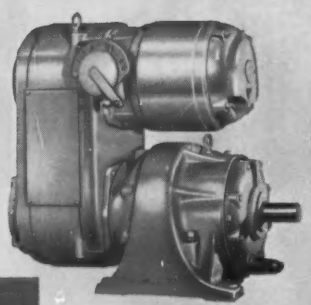
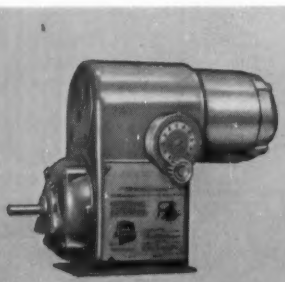


UPRIGHT VARIDRIVE MOTOR
WITH VARITROL AUTOMATIC CONTROL

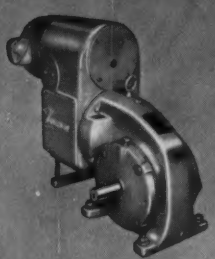


VARIDRIVE
WITH INTEGRAL GEARING, MOTOR AND TAKE-OFF SHAFT SAME SIDE

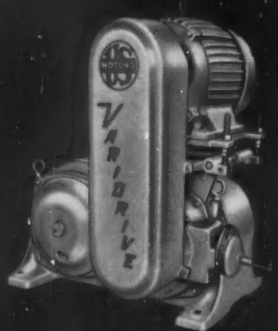


SMALLEST VARIDRIVE
1/4 TO 1 H.P.
WITH HAND CONTROL ASSEMBLY

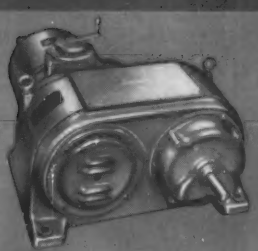
DUAL BELT UPRIGHT VARIDRIVE WITH TOTALLY-ENCLOSED MOTOR AND ELECTRICAL REMOTE CONTROL



VARIDRIVE MOTOR WITH INTEGRAL RIGHT-ANGLE WORM-GEARING



MOTOMOUNT VARIDRIVE
WITH STANDARD FOOT-MOUNTED MOTOR



HORIZONTAL VARIDRIVE MOTOR

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P.O. Box 2058, Los Angeles, California or Milford, Connecticut

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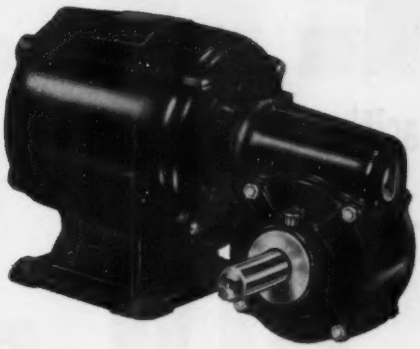
MOTOR USER'S CASE HISTORY

"We ran accelerated life tests... selected Bodine Motors"



... HALOID XEROX INC.

"Before we selected a Bodine fractional horsepower motor to power our XeroX 914 Office Copier, our Research and Development Division conducted accelerated life tests. The results were favorable. This, plus our past experience with Bodine's dependability, made it clear that Bodine Motors should power this piece of office equipment. Also we find that Bodine's conservative rating gives us trouble-free performance even when used at full rating."

... Dr. John H. Dessauer, Executive Vice President
in Charge of Research
and Product Development, Haloid Xerox Inc.

Here's the XeroX 914 Office Copier . . . powered by a Bodine Fractional Horsepower Motor

This remarkable new copier automatically reproduces copies of letters and other documents on ordinary unsensitized paper. For single or multiple copies . . . as many as six a minute . . . you just dial the number of copies you want, push a button, and that's it. The main drive of the XeroX 914 Copier is powered by single reduction, right angle worm gear, speed reducer motor . . . by Bodine.

Bulletin describes late model business machine motor.

Here's the story of Bodine's latest model business machine motor . . . the FSE-23. It's only 2 5/16" high . . . weighs only 1 pound 11 ounces . . . and delivers plenty of power, Designed for economical, high volume production. Ask for your copy of Technical Bulletin #1034. Bodine Electric Company, 2508 West Bradley Place, Chicago 18, Illinois.

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fractional BODINE horsepower

MOTORS

... the power behind the leading products

Circle 404 on Page 19

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RS P.I.V.

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All-metal drives use single-roll chains to achieve positive, stepless, infinitely variable speed control

With a unique chain design and force lever system, Link-Belt RS P.I.V. drives represent a major advance in direct-drive variable-speed transmission. It's the most compact mechanical 50 horsepower variable speed drive on the market.

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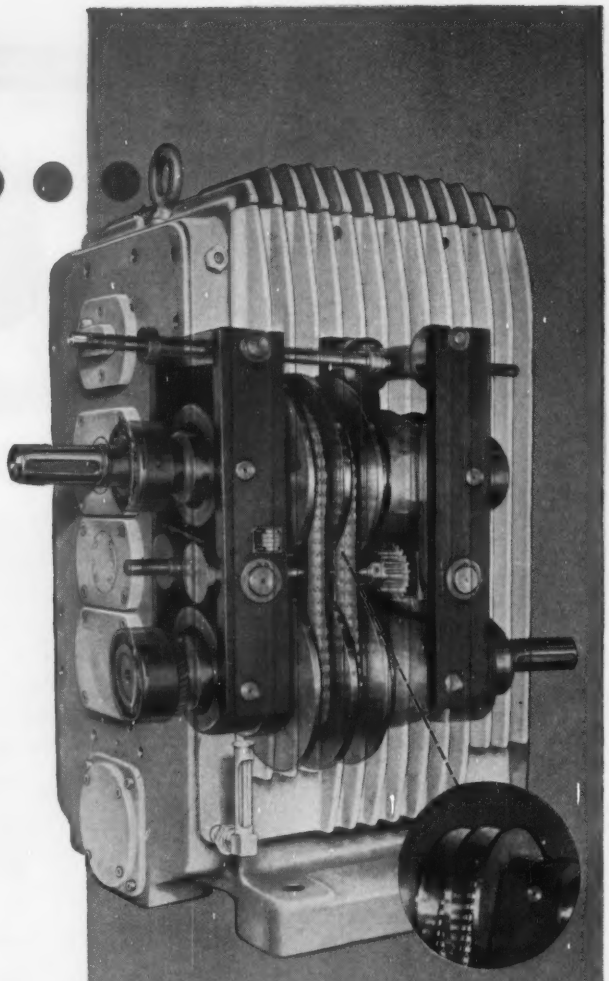
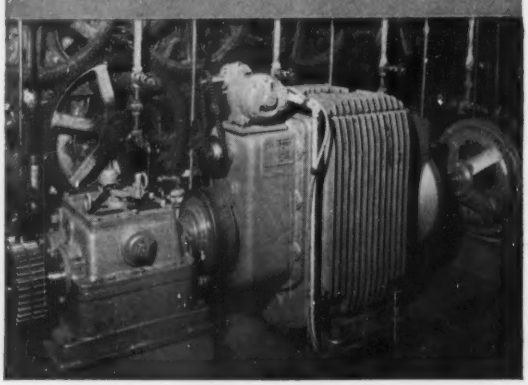


RS-33 P.I.V. with twin chain arrangement for capacities to 50 hp. Inset shows close-up of unique all metal single roll chain construction.

47-ROLL PAPER-MAKING MACHINE uses Link-Belt RS P.I.V. on primary drive. The RS P.I.V. powers a two-speed gear drive which enables paper speeds to be varied over two ranges . . . 4 to 16 yards per minute and 12½ to 50 yards per minute.



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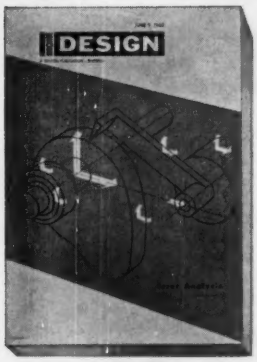

Front Cover: Big and little arrows are used by artist George Farnsworth to depict the principle of error summation in a simplified mechanism. Details of this vectorial technique of error analysis are explained and demonstrated in S. B. Tuttle's article on Page 152.

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ENGINEERING NEWS

"Renaissance in Copper" Promised by Producers

HOT SPRINGS, VA.—Amid the flurry of new and exotic materials developed during the last few years, some of the conventional metals have been all but lost in the shuffle, at least from the standpoint of publicity. This situation is causing a major reappraisal of promotional and technical programs on the part of several basic-metal producers.

At the recent annual meeting of the Copper & Brass Research Association, speakers emphasized "an abundance of new and exciting ideas for copper products." Some of the ideas merely require engineering development; others, admittedly, will demand considerable research. Here is a preview of projects now under active development by the newly formed Copper Products Development Association—an organization formed by copper producers to put their favorite metal back in the forefront of design:

- Stainless copper, developed, perhaps, by metallurgical surface treatment.
- Organic and inorganic protective finishes for copper, brass, and bronze.
- Abrasion-resistant plastic finishes for copper products and combinations of copper with the newer plastics and glasses to give materials superior properties and greater esthetic appeal.
- Increased uses for copper in cast iron and for alloying with steel.
- Combinations of copper and aluminum for electric power applications.
- Development of copper chemicals for use in industry and agriculture.

Copper powder metallurgy is another promising area, according to CPDA. "There are a number of applications at the present, and whole new lines of products made from copper powder seem imminent. Possibilities also exist for products based on copper fibers and crystals."

Tilt-Axis Hemisphere Pinpoints Pilot

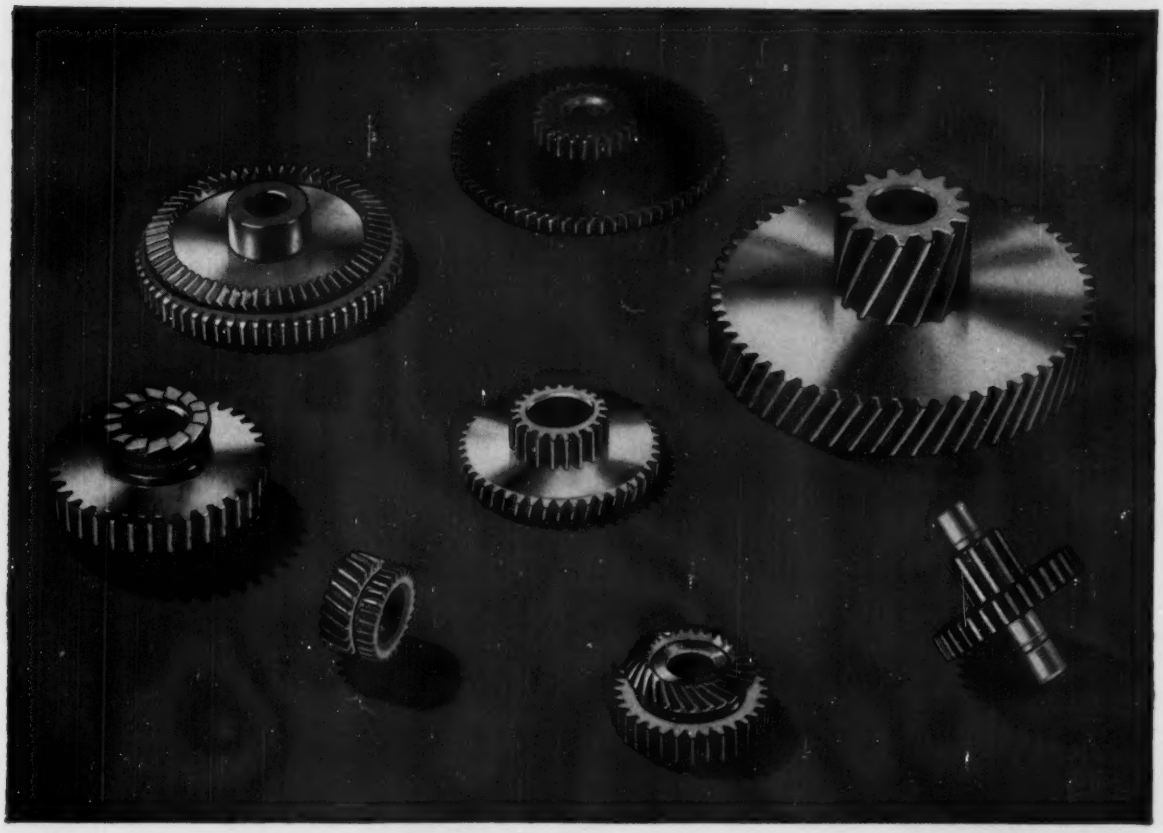
Semiglobal pilots can dispense with complicated calculations when they use a navigation system now in the experimental stage. A transparent plastic hemisphere is etched photographically with a map of half the world; a beam of light illuminates a 400-mile circle, projecting it on a flat screen in front of the pilot. The hemisphere is automatically turned on its axes by a computer so that the illuminated circle is always centered on the plane's position. International Business Machines Corp., New York, presently refining the basic system, says that a similar device could be used in space navigation. A stellar map would replace the world map, and a telescopic view from the spacecraft would be superimposed on the flat screen. As the two pictures lined up, a computer would automatically determine position.

Communication Trails New Engineering Knowledge

NEW YORK—While engineering and scientific knowledge increases exponentially, the techniques used to communicate the flood of new data, new ideas, and new information are improving at a decidedly slower rate. This lag can be extremely costly to individual companies who find themselves duplicating work already done by other groups, or who find their products suddenly obsolescent, or their progress checked by the lack of new materials, ideas, and methods to meet the changing needs in their particular field.

The problem was recently examined in a seminar at New York University (Subject: "The Critical Million—How to Talk to the Nation's Scientists and Engineers") where experts in the field set out to define the "ideal" communications program.

One of the seminar speakers, Mr.



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SEND FOR G.S. *illustrated folder! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

44 Years of Specializing in Small Gearing!

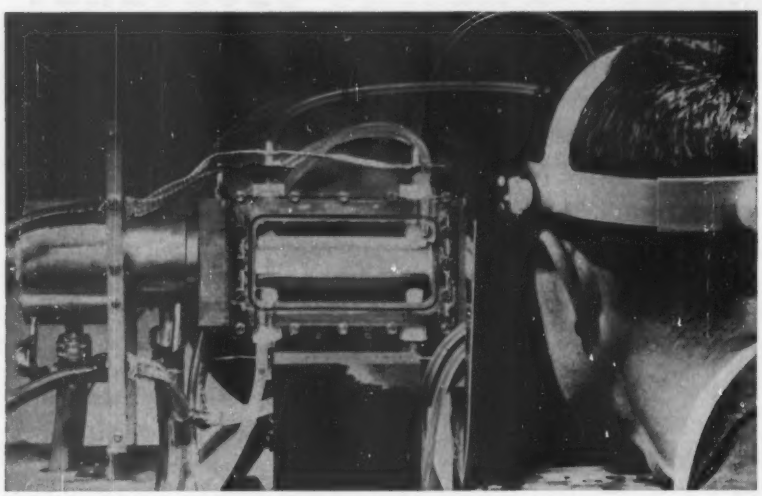
Frank Coss, vice president, Scientific/Technological Communications Inc., suggested that the basic need is for better communication, not more communication. And the individual company can do much to promote this idea. Mr. Coss proposes that company managements:

- Recognize that the one million scientists and engineers in this country constitute a separate and distinct audience, relatively small in number, but critical in importance, who are not amenable to conventional mass communications methods and philosophies.
- Develop for the company a separate, comprehensive program of communication to and from this technical community. Factor into it the traditional communications methods, those the company already may be using. But look also for new and effective ways in which to disseminate and gather information. Make use of specialists and consultants who can aid in this effort.

Among the vast array of communications tools and procedures that companies can use, one of the most effective is personal contact. According to Mr. Coss:

- Scientists and engineers working in the same company should be encouraged to meet and exchange information and ideas, and they should be encouraged to talk with their counterparts in other companies.
- Companies in one geographical area might pool their information sources, with each company specializing in a particular field. They could also set up inter-company seminars, meetings, roundtables, conferences on subjects of mutual technical interest. And they could underwrite a local club or group for informal and social contacts among scientists and engineers.

The vast technical press is a major communications channel that should be better understood and utilized, says Mr. Coss. Companies should study the various types of technical magazines available, establish liaison with their editors, and encourage company technical and scientific personnel to contribute papers and reports to appropriate publications and journals.



Crossed-Field Tunnel Gives Long-Term Tests

Hypersonic-test durations move out of the split-second range with the development of a new Allis-Chalmers "cross-field acceleration" wind tunnel. Designed to test missile materials, the prototype facility has run continuously for as long as 20 minutes. (Older "blow-down" tunnels give millisecond test times.) The test gas—a spark-generated plasma—is first speeded to supersonic velocity by a convergent-divergent nozzle. Further acceleration to hypersonic speed is accomplished by crossed magnetic and electric fields. Selective control of plasma generator and crossed fields gives wide choice of test-gas velocity and temperature. A-C developed the new facility in co-operation with MHD Research Inc., Newport Beach, Calif.

Topics

January in June: A British manufacturer, Mobile Jet Dispersals Ltd., has announced a snow-clearing machine which can dispatch a 6-in. deep layer of snow on a 9-ft front at the rate of 4 mph. Also capable of doing away with 7-ft drifts, the Snow Locust has an adjustable working head on the front with swirl-type oil burners which are pressure-fed with oil and air. After the snow has been melted, a rotary brush and a squeegee sweep away slush and water.

• • •

New light on an old civilization gives a clue to its age. Dr. George C. Kennedy and Dr. Leon Knopoff, of the University of California Institute of Geophysics, have dated pieces of pottery and lava as old as 100,000 years by inducing thermoluminescence, which is caused by radioactivity in materials. Heating a substance to below the point at which light is given off releases thermoluminescence —a result of freeing electrons trapped in the solids. Number of electrons trapped increases with age of the material; therefore, the glow indicates relative age of the material.

• • •

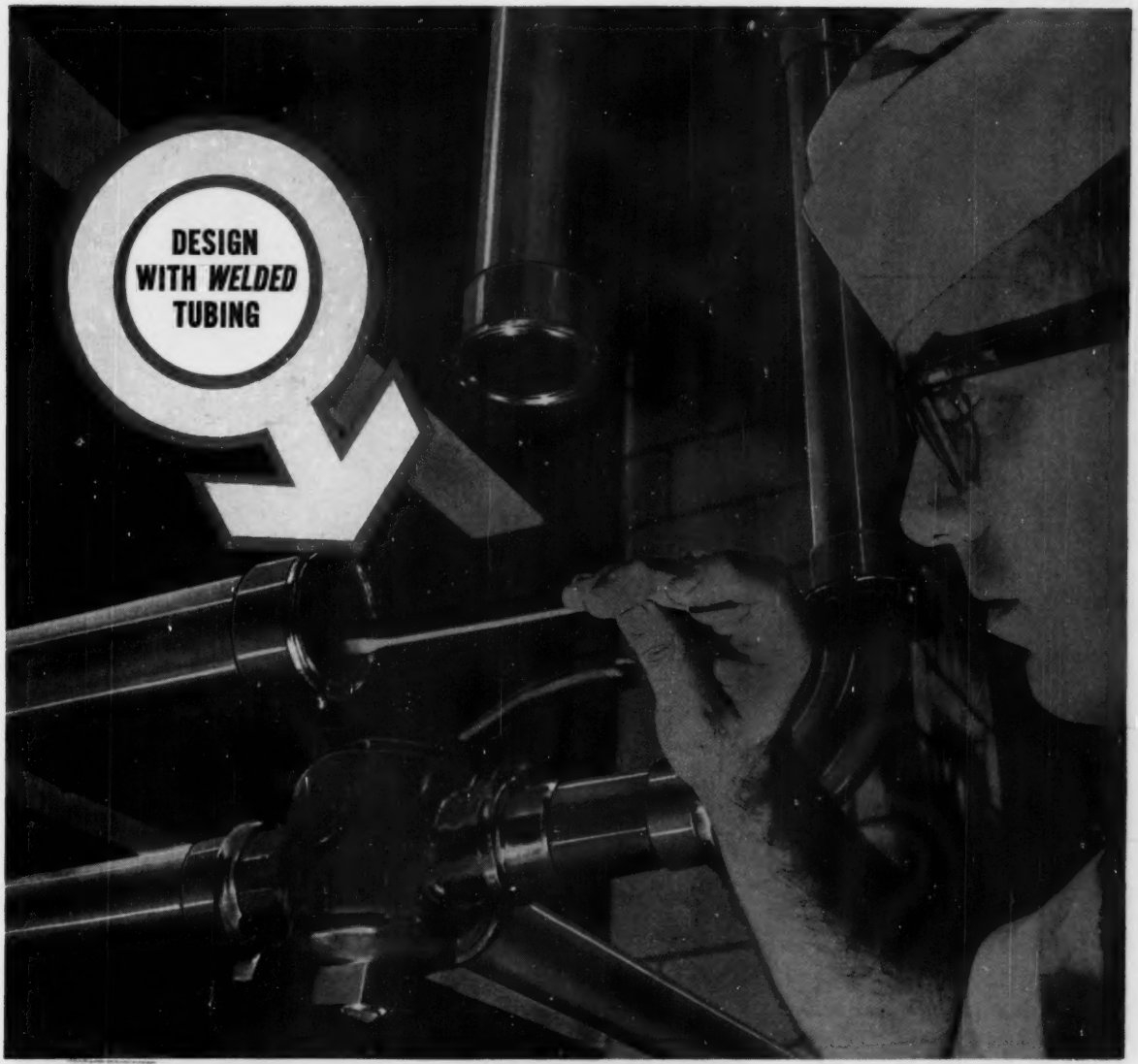
From the city of brotherly love comes an invention that makes it almost fun to be hit by a car. A pedestrian protector developed by David Gutman consists of a cushion across the car's hood and spring-operated telescoped tubes which, when released, grasp a struck pedestrian and keep him from falling to the pavement. The tubes are out of sight when not in use.

• • •

Bread paper may soon be made of polyethylene. This was one of the potential uses for plastic suggested by some 1200 consumers polled in 17 major cities. Other applications suggested for plastics were milk carton coating, book covers, toothpaste tubes, and thread spools.

• • •

The wheels of justice are grinding exceedingly faster in New York County, thanks to three IBM machines. A key punch and electric impulse machines, which handle punch cards, have taken over the job of selecting jurors. The new system is estimated to be nine times faster than random selection of paper ballots from a barrel. By freeing clerks from paper work (they'll have more time to interview prospective jurors), the system should also apportion jury duty more equitably, increase the number of jurors summoned, and foil those who would dodge jury duty. In its first assignment, the equipment selected and typed a list of 1300 jurors in 25 minutes—a job that would have taken 7 manhours.



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SOUND, SMOOTH SURFACES—easy to clean!

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These inherent qualities confer ease and speed in complex fabrication. Welded steel tubing is adaptable to all types of fittings. Every type of joint can be produced. Forming is precise because welded tubing is dependably accurate in dimension in every size, length after length.

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LC-602

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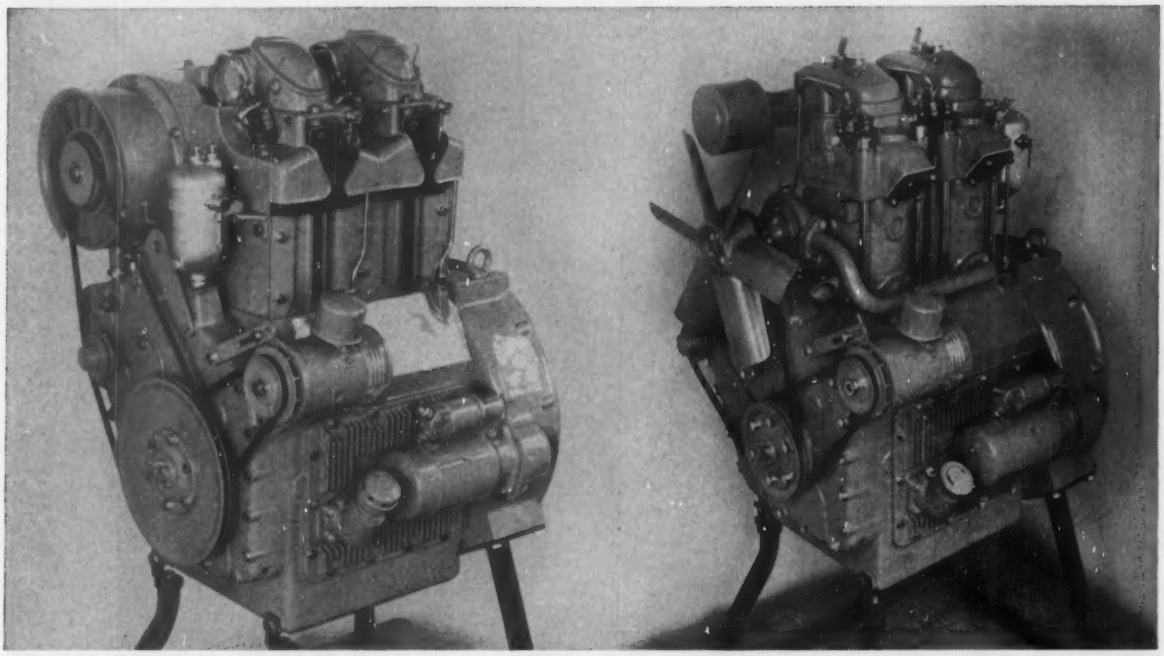
Convertible Cooling for Light Diesels



Eight out of ten parts can be interchanged between water-cooled and air-cooled models of a new German diesel-engine line. Parts for the two types are exactly the same except for cylinder heads. Designed by Daimler-Benz AG, Stuttgart, to cut down replacement stocks needed by industry, engines have from one to four cylinders. Simple and rigid, all models feature alternate (front or rear) power take-offs and operating speeds of 2000 rpm. Power ratings vary from 20 to 80 hp. Two-cylinder engines are pictured (air-cooled engine, left; water-cooled, right).

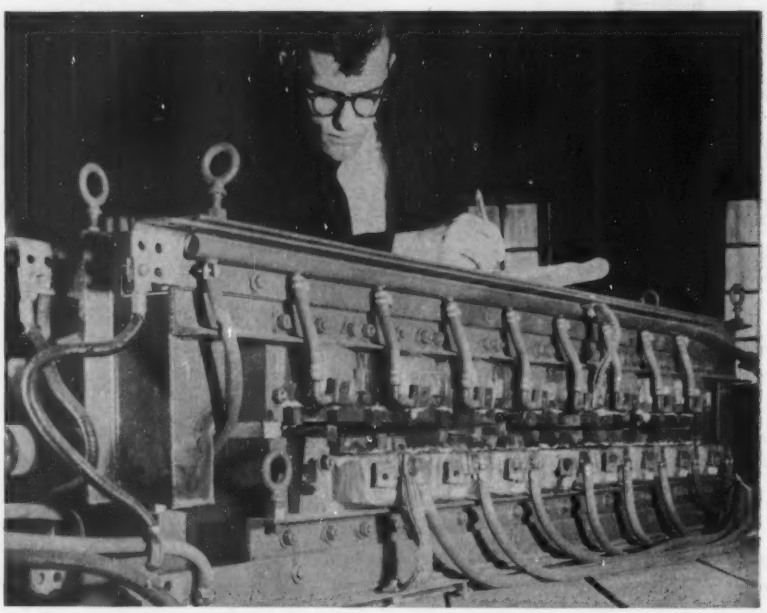
Continuous Annealing Process Upgrades Strip Metal

PITTSBURGH — Flash annealing of strip and sheet products may be the long-sought continuous-production process for the sheet-metals industry. The development, by Penn Induction Corp. and Pennsylvania Electric Coil Corp., uses a technique called "transverse flux induction."

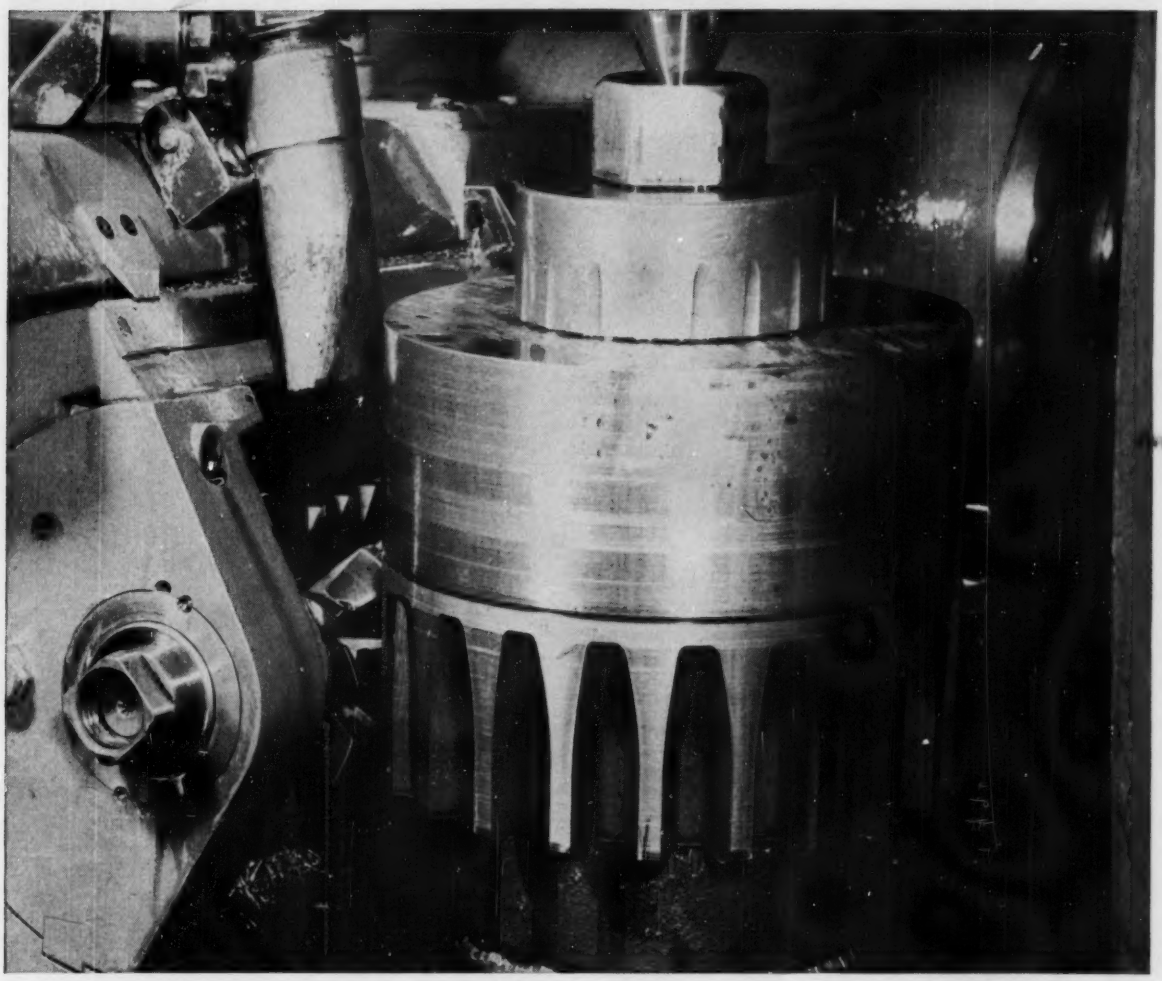
In conventional annealing processes, metal coils are stacked in gas or oil-heated furnaces. Since strips are not unwound, heat must work towards the center through successive layers of metal. This means that outside layers remain at annealing temperatures longer than those in the center, so that grain growth varies considerably from one end of the coil to the other.

Although metallurgists knew that flash annealing produced a uniform fine-grained metal, no way of applying uniform heat could be found.

However, after a four-year study, PIC learned how to overlap flux from adjacent coils so as to eliminate cold gaps in the moving metal strip.



Unwinding, heating, cooling, and rewinding all at the same time, coils can be stress relieved faster and more uniformly with the aid of a flash heater. Grain sizes produced are about a quarter of the size of those in strip metal from a conventional annealing oven, giving a sheet that is easily deep drawn.



*Inland Ledloy License

Aristoloy Leaded increases hob speed 50%... prolongs tool life 50% for Boston Gear

Together these add up to 100% satisfaction with Aristoloy Leaded* steel. By switching to Aristoloy Leaded, Boston Gear now machines three 7" Spur Gears per hour. Best production achieved on the steel previously used was two per hour.

With Aristoloy Leaded, 24 gears are cut before the hob needs sharpening . . . only 16 were possible with other steel used by Boston Gear.

Strength and hardness of the finished part show no detectable difference in physical properties from the unleaded steel used earlier.

For complete information about Aristoloy leaded or standard analyses carbon, alloy, and stainless grades, write for booklet entitled, "A Complete Line of Leaded Steels," and new Products and Facilities Catalog.

ARISTOLOY STEELS

DIVISION OF
COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

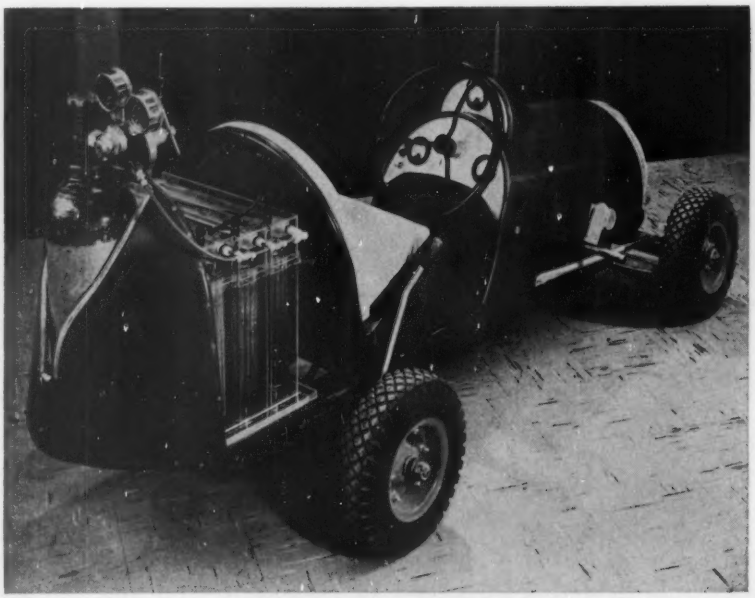
Fuel Cells Start Rolling

PHILADELPHIA, PA. — Mass produced fuel cells, many times more powerful than any demonstrated so far, may result from an agreement signed recently. Calling for the development of a fuel cell to power industrial trucks, the agreement is between Electric Storage Battery Co., and twelve material-handling equipment manufacturers.

Exide announced that some major obstacles have been overcome in the direct conversion of zinc-oxygen chemical energy to electricity, and that their cell is strikingly different from previous gaseous-fuel cells. Advantages of the new cell are claimed to be:

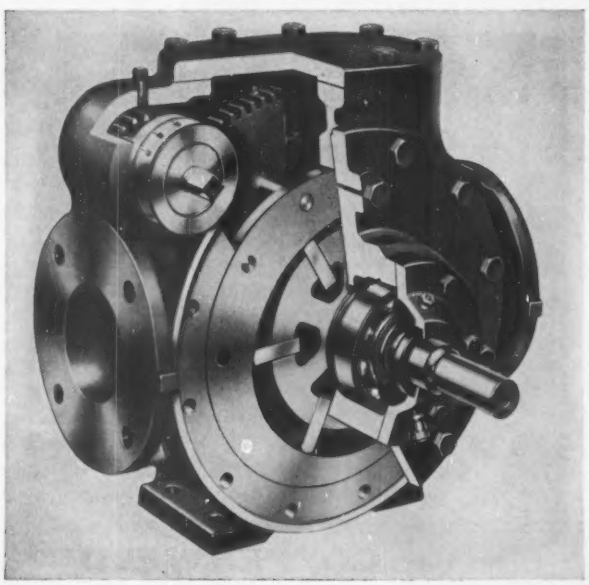
- Operation at near-normal temperatures and pressures
- No waste products to be removed
- No theoretical limit on physical size or shape
- Can be scaled up or down in size for various power requirements

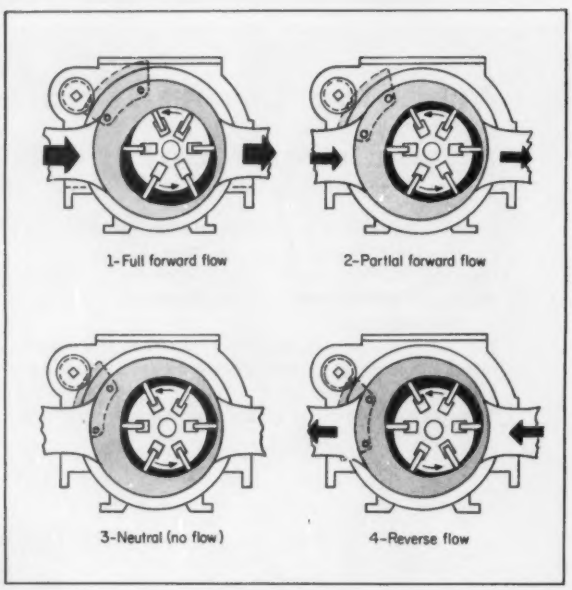
Oxidizing zinc in a potassium hydroxide electrolyte as oxygen is admitted under low pressure, the cell can power a heavy industrial truck continuously for 16-24 hr. Then, the cell can be recharged electrically (reversed), to restore it to full power potential. Alternatively, the discharged zinc electrode can be replaced with a new one for more continuous operation, and the used one turned in for credit.



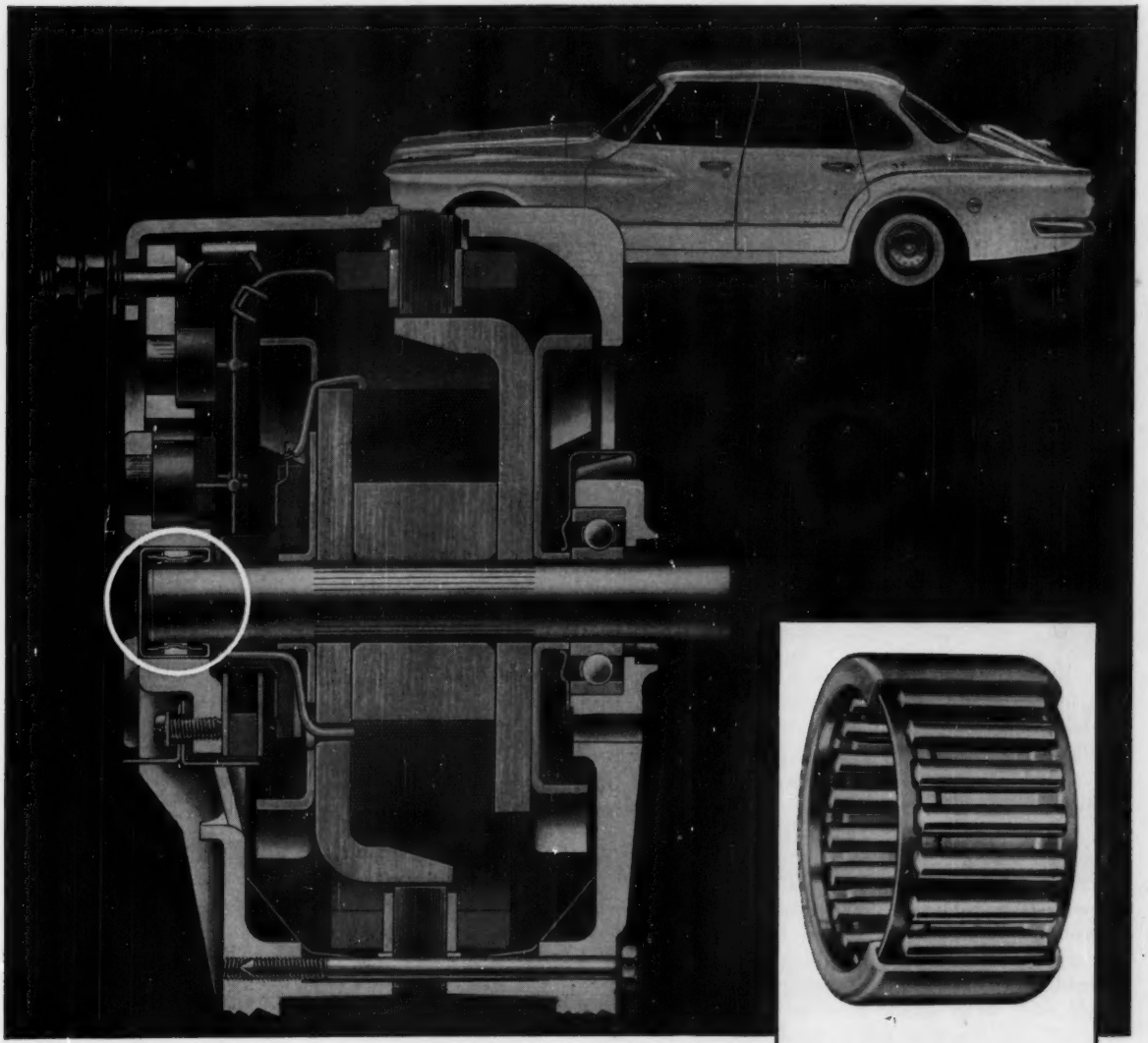
Power for racer is provided by the prototype of an Exide zinc-oxygen fuel cell. Tank contains oxygen that is admitted under low pressure into the cell, where power is produced by oxidizing zinc fuel in potassium hydroxide electrolyte.

Eccentric Liner Varies Vane-Pump Flow Rate





Turn of a dial will vary the flow rate of a rotary pump from full capacity forward to full capacity reverse while the drive motor continues to run at constant speed. The dial operates a rack and pinion which rotates an eccentric liner to change the pump's effective displacement. Blackmer Pump Co., Grand Rapids, Mich., expects to find applications where adjustable delivery rates are desirable, or where one pump must deliver liquids of different viscosity, such as diesel oil and kerosine. Pumps will be manufactured in three sizes with capacities up to 450 gpm.



Torrington Drawn Cup Roller Bearings Used in Valiant's Alternator

Compactness, efficiency, economy, reliability . . . these are outstanding features of Chrysler Corporation's exciting new small car . . . and of Torrington Drawn Cup Roller Bearings. Used by Chrysler in the Valiant's new alternator system for electrical power generation, these bearings provide smooth, trouble-free operation and long service life without need for relubrication.

Torrington Drawn Cup Roller Bearings offer performance advantages in all types of generators and appliance motors. The cost is remarkably low . . . in many cases, armature bearing costs have been lowered by as much as 50%. For advice on the application of Torrington Drawn Cup Roller Bearings to your specific problems, call or write your nearest Torrington district engineer.

Armature-mounted Torrington Drawn Cup Roller Bearings offer these outstanding advantages:

- Highly efficient roller guidance
- Ample provision for lubricant storage and circulation
- High capacity in small cross section
- Long pre-greased service life
- Outstanding efficiency at high speeds
- Easy mounting by press fit
- Simple housing design
- Low unit cost

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

Designers Sell Man Short Says U-M Psychologist

DETROIT—Too many designers of man-machine systems start with the machine, *then* see if there's anything left over for the man to do. "This is very costly . . . really no more reliable in the long run than starting with the man first, then filling in what he can't do with machines," says Dr. Ward Edwards, staff psychologist, Willow Run Laboratories, University of Michigan.

Challenging the machine-centered philosophy of design, Dr. Edwards blamed the growing reluctance to use human skills on three overrated axioms:

- Man is unreliable; therefore, designers should never require his services except as a last resort.
- Man's intellectual skills—while handy when a task can't be mechanized—are poorly understood. Call in an expert to worry about his training.
- When allocating a function that can be performed by man *or* by machine, assign it to the man *only* if he can approach the machine's performance specifications.

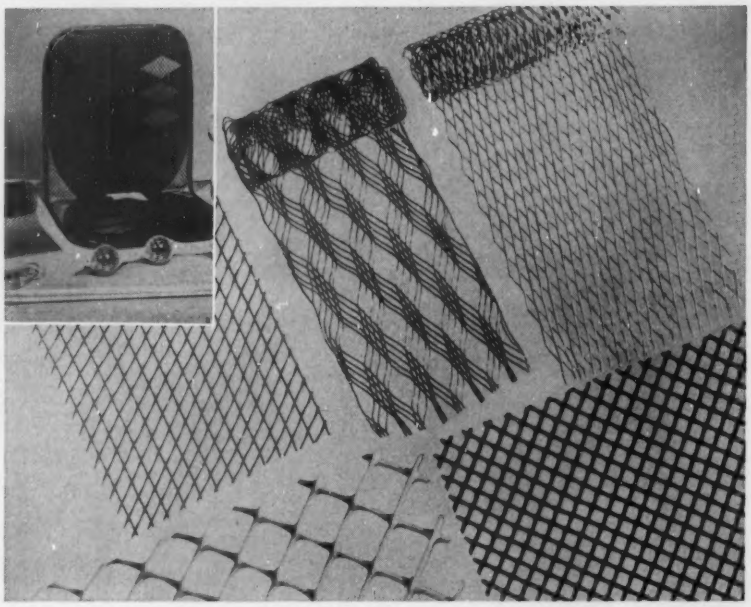
"Obviously I am not arguing that everything should be manually controlled," says Edwards. "But I am arguing that before anything is made automatic, the designer should ask: Why should it be automatic?" If there is not a good answer in terms of system effectiveness, operator satisfaction, reduced cost, then the automatic feature is probably unnecessary.

He cited four basic skills at which man can excel any machine:

- Pattern perception—No system now available contains any alternative to man for interpreting complex, patterned displays. (For example, nobody has designed a machine that can pick objects of military interest from a photograph.)
- Reliability—Man makes more mistakes than machines, but when he's trained, he isn't likely to repeat the mistake. He also detects and corrects his own errors.
- Judgment—The ability to translate uncertainty into probability.
- Long-term memory — "If you want to remember small amounts of material for short periods, use computers," says Dr. Edwards. For large bodies of information, where cross-indexing is required, or for fast access, rely on human memory.

Summing up, Dr. Edwards says: ". . . a human-centered design philosophy is, in the long run, inevitable for all civilian man-machine systems. As long as we have lots of men around, we are going to have to use them. And as long as we are going to use them, we might as well use them right."

Thermoplastic Netting in Sheets and Tubes



Three basic patterns for rigid and flexible Vexar plastic netting are, left to right, twill, plaid, and diamond. The two diamond patterns at the bottom show the wide variety of mesh sizes and filament diameters possible. Insets illustrate some of the applications investigated to date.

WILMINGTON, DEL.—Extruded directly in net form, new plastic netting has intersections between strands that are stronger than the strands themselves. For the first time, these intersections are an integral part of the material, rather than an interwoven or heat-sealed addition. And properties of the screen-nets can be widely varied to provide a wide range of sheets or tubes.

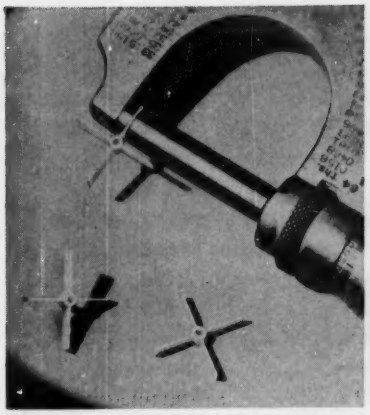
Mesh size and pattern, filament diameter, strength, stiffness, and color can all be varied. The end product retains chemical and physical properties of the basic resin. Initial versions, made from polyethylene resins, are chemically inert, flexible, and resist moisture, rot, and mildew.

Manufactured by the Film Dept. of Du Pont Co. and called Vexar netting and piping, the plastics can be made with strand diameters from 15 mils up. Mesh size can be varied from 16 counts to the inch—smaller than normal window screening—to more than one inch between strands.

Three basic patterns are available: 1. Diamond—intersection strands are on the bias to the direction of extrusion. 2. Twill—one strand parallels the extrusion direction, but the other is on the bias. 3. Plaid—version of diamond in which strands are grouped and spaced unevenly.

Early applications center around the protective/decorative utility of the materials. Examples:

- Flat and flexible black netting in portable auto seat pads.
- Semirigid piping (in a variety of colors) used as protective sleeves over highly polished tubular machine parts.
- Protective sheaths over metallic heating elements (to decrease the incidence of burned fingers).



New Precision for Ceramics

Sub-miniature ceramics can now be manufactured to what are called "impossible" tolerances. A new process, developed by American Lava Corp., Chattanooga, Tenn., allows designers to call for precision components in any of the AlSiMg compositions. For example, the webs (above) are held to within 0.001 in., and tolerances on concentricity are comparable. The process has been thoroughly checked out and proven in production, ALC spokesmen report.

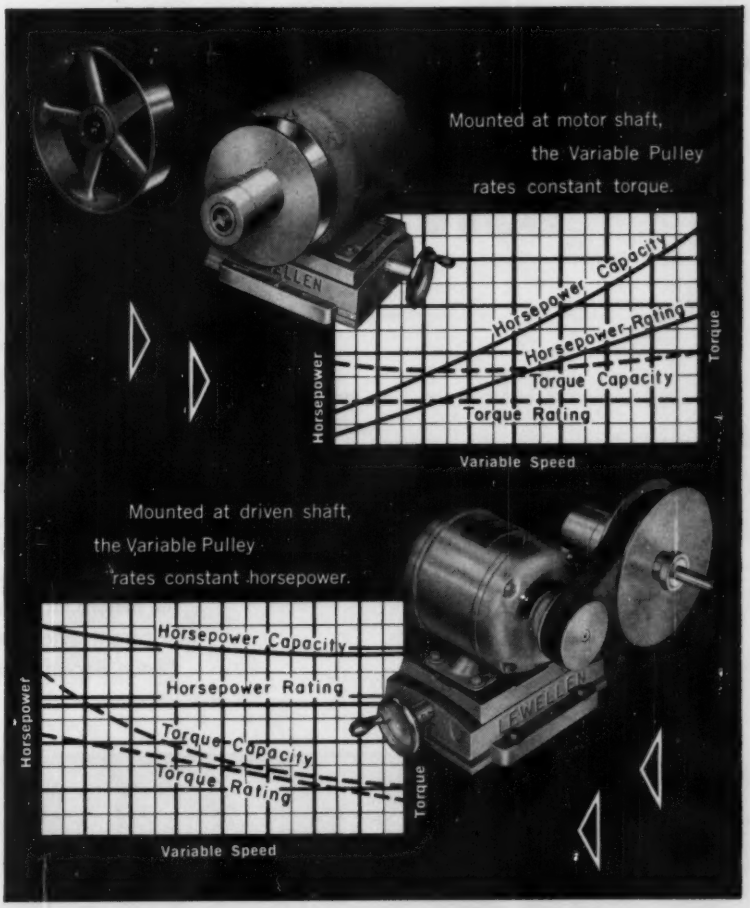
Infusible Foam For Ablation Coating

NORTH HAVEN, CONN.—A heat resistant urethane foam may broaden horizons in the fields of structural insulation for missiles and high-speed planes. The material, developed by the Carwin Co., is dimensionally stable up to about 500 F. Some weight loss and shrinkage occur at these temperatures, but the company claims their material retains 45 to 65 per cent of initial compressive strength even at 600 F. The foam will not revert to a liquid or plastic state although, at about 1000 F, carbonization occurs.

The new foam is an isocyanate, a mixture of low-molecular-weight polymers. Volatility is correspondingly low, so that the problem of toxicity is materially reduced.

Unrestricted-rise densities available in the series range from 3 to 40 lb per cu ft. Coefficient of thermal conductivity of the 3 lb per cu ft foam at 325 F is only 0.26, and high dielectric strengths are also retained at this temperature.

Suggested uses are for vibration damping and as an ablation coating for re-entry vehicles.



LEWELLEN

VARIABLE PULLEY HORSEPOWER TORQUE CHARACTERISTICS

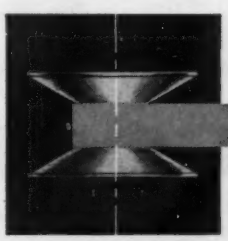
The LEWELLEN Variable Pulley may locate at motor shaft or driven shaft.

The location chosen obtains constant torque or constant horsepower characteristics, and adapts the Variable Pulley to the work load pattern.

Speed ranges of 3:1 and 4:1 are available. Fastest speeds may exceed motor speed.

Ratings are fractional to 25 H. P. Class II—1.4 service factor applies to all ratings.

There are several other characteristics of the LEWELLEN Variable Pulley that make it particularly useful and adaptable for accomplishing variable speeds.



We would like for you to have our Catalog 70 if you are interested.

LEWELLEN

Manufacturing Company, Columbus, Indiana

Distributors in all Industrial Areas

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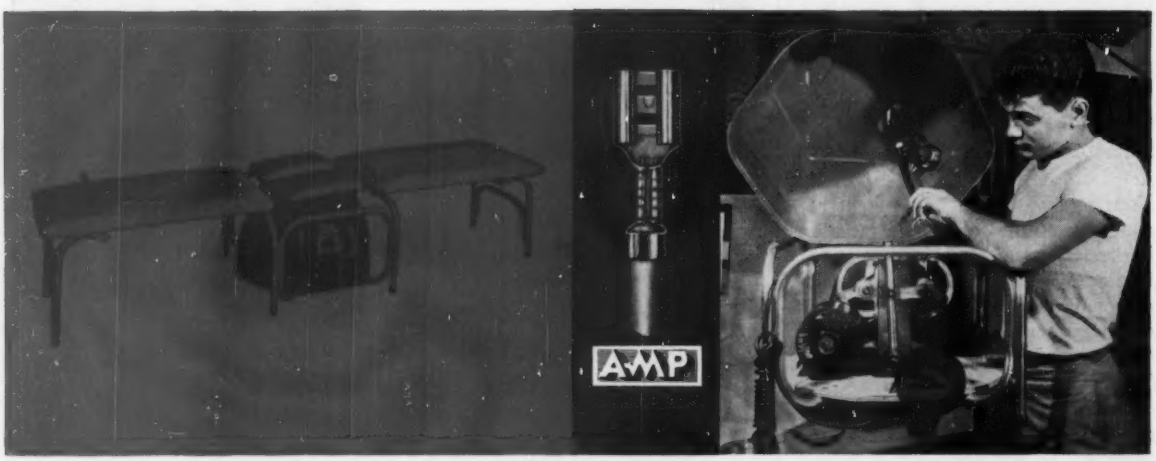
PROBLEM:

Engineers at the Bobrich Products Corporation, Beacon, New York (manufacturers of automatic electric blankets and the Golden Touch Massage Lounge) were trying to make reliable circuit connections the hard way. They raised the cover turret (illustration, below) on their massage lounge a few inches then poked a hot iron through the narrow opening to solder the leads. Trouble was it took too long, it was hard to see and they were never sure that a reliable, permanent connection had been made.

SOLUTION:

The firm eliminated its problem very neatly with the A-MP Faston Receptacle. Bobrich now terminates all leads solderlessly **before** they're installed. Production rates have skyrocketed to thousands per hour with the A-MP Automachine—and, when the turret is fitted over the motor unit, it needs to be lifted only a few inches to permit quick manual insertion of the A-MP Faston Receptacles onto the waiting tabs.



RESULT:

Bobrich got a tremendous boost in production, saved expensive time and now has assured, uniform reliability with each Faston.

You, too, can have all these advantages by using A-MP Faston Receptacles in your circuits. For the full story, including technical data, send for our Faston Catalog.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

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Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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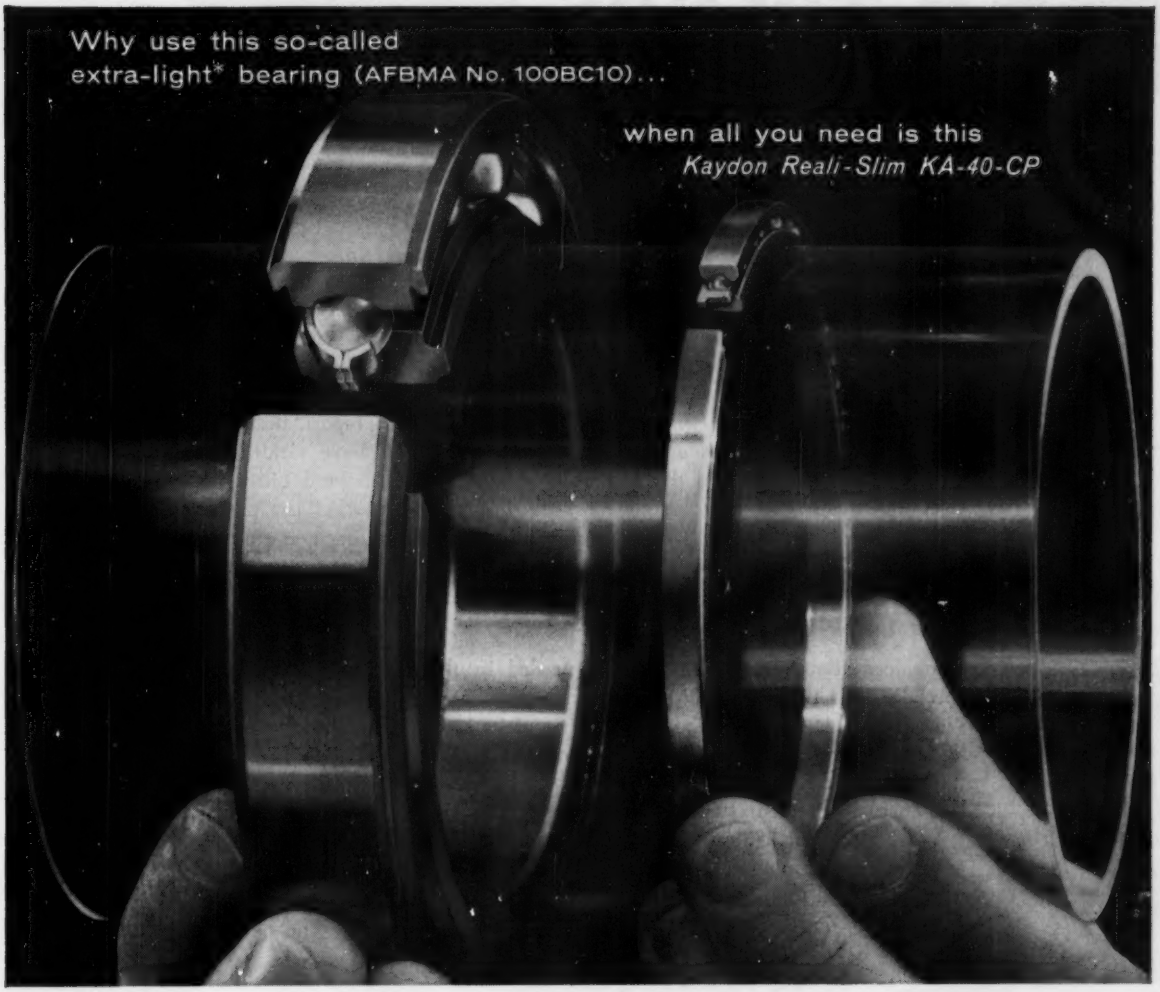
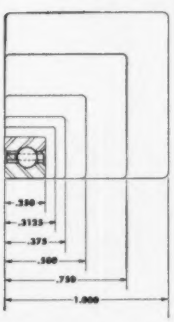


News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Kaydon's volume production cuts prices as much as 76%, depending on size. Write for free, fact-filled "CP" bearing bulletin — with prices!

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coming: instant steel

Open-hearth furnaces can be doubled in capacity, and heating times cut in half by a new process that completely revises open-hearth steelmaking. Developed by Ford Motor Co., and still in the experimental stage, the technique achieves higher temperatures and faster chemical reactions by heating the steel with oxygen-fuel "lances" and replacing traditional limestone with burned lime. Production will be limited, Ford spokesmen report, until new oxygen-producing facilities are completed, but trial heats have yielded 100 tons per hr from furnaces that normally produce 40 tons. Ford hints that steel-price reductions may become possible, but points out that the process won't affect cost of scrap steel and hot iron, or cost of rolling and shaping.

keeping up with the computers

Convinced that a drastic increase is needed in the number of "computer specialists" in the U. S., IBM will open a new Systems Research Institute in New York this fall. Described as the first of its kind, the institute will be a "graduate level school" aimed at turning out people qualified to find computer-system solutions to the most complex business and scientific problems. Entrance requirements will be "stiff," according to IBM president, Thomas J. Watson Jr. Curriculum will include systems design, advanced programming, and business-simulation techniques. Enrollment this fall (limited to IBM personnel) will total 30 students, is expected to grow to 400 students annually and include outside applicants.

astronauts and icepicks

Freezing liquids and gases may be one way to relieve the space-traveler's storage problems, once he leaves the earth's atmosphere. Donald H. Robey, Convair (Astronautics) design specialist, reports that volatile fuels could be stored externally on the shadow side of a space vehicle where they would act as a meteor deflector. Frozen waste products, mounted on the front of the vehicle, could serve the same purpose. Further exploring the properties of ice in space, he suggests ice-welded structural designs, and notes that returning space ships could be coated with ice to help absorb the heat generated by friction during re-entry.

additives build up solid lubes

Solid lubricants with 20 times their normal load-bearing capacities have been produced by General Electric scientists through the use of several inorganic additives. In one laboratory test, silver sulfide (the additive) was "incorporated" into molybdenum disulfide and used as the lubricant for a $\frac{1}{8}$-in. diameter chrome alloy steel hemisphere sliding over a mild steel surface. Load bearing capacity of the souped up lubricant was 5.3 kg, versus 0.25 kg for pure molybdenum disulfide. GE researchers report that even better results are obtained when the lubricants are used on relatively hard surfaces, such as chromium. They also report that various other additives have proved equally effective in bolstering the strength of several common solid lubricants.

more automotive jobs for plastics

Gasoline tanks will probably be the next auto component to "go plastic." Dr. Herman Mark, professor of organic chemistry, Polytechnic Institute of Brooklyn, recently told SAE members that tanks made from fire resistant fiberglas reinforced polyesters could provide an equivalent volume at one fifth the weight of steel tanks. No major fabrication problems would be involved—adhesives would seal all the joints. Other possibilities are plastic windows and windshields. Some plastics now have optical properties as good as glass, and, in addition to the weight advantage, would be ice-free in winter because they are hydrophobic.

doctor-designers

If any significant progress is to be made in bridging the gap between medicine and the physical sciences, a new breed of professional worker will be needed who is competent in both fields. This could well lead to a new profession, known as medical engineering and backed by formal academic training, according to Hans H. Zinser, M.D. of Columbia University's College of Physicians and Surgeons. Dr. Zinser told a recent medical electronics session in New York that a curriculum in medical, or biomedical, engineering might well comprise a four-year undergraduate program and a six year post graduate schedule leading to PhD. Emphasizing the importance of medical engineering, Dr. Zinser said: "Technology can derive very real gains from the intimate analysis and replication of biological devices. In the field of transducers, orientation mechanisms, and information integration, many biological systems transcend any mechanical systems thus far devised."

nitrogen gets a metalworking job

Fostered by the missile and aircraft industry, explosive forming continues to gain acceptance throughout U. S. industry. The same situation is apparently true in the USSR, where the process is taking on some new twists. Soviet engineers report that they are die-forming metal parts through the use of nitrogen. The equipment they utilize takes advantage of the shock-type expansion created when liquid nitrogen is suddenly permitted to expand at room temperature. Transition from liquid to gaseous state occurs in one second. One liter of liquid produces 609 liters of gas, and pressure buildups of over 8000 psi are reported.

dyed diecastings

Although it is generally assumed that aluminum color-anodizes easily, aluminum diecastings have been a notable exception. But the Hamilton Die Cast Co., Hamilton, Ohio, claims an alloy and a process of theirs will do the trick, and may cause some second thinking in design offices. The new alloy —not pure aluminum, the company notes—is stronger and less brittle than the usual diecast alloys. Colors obtained are crisp and controllable—but Hamilton Co. isn't talking about the details of their process.

NEW SUPER STAINLESS STEELS SHED CORROSION

PH55A and PH55B are the new super stainless steel alloys developed by Cooper Alloy Corp. to resist those corrosion-erosion, corrosion-abrasion attacks which cannot be handled by most extisting alloys.

These alloys have high strength and high hardness even at temperatures elevated to 1000°F-1400°F. PH55A is particularly recommended for applications where pitting corrosion is the problem. PH55B, more ductile, is suited for applications where corrosion resistant parts are subject to stress and shock. Write today for Form PH55.

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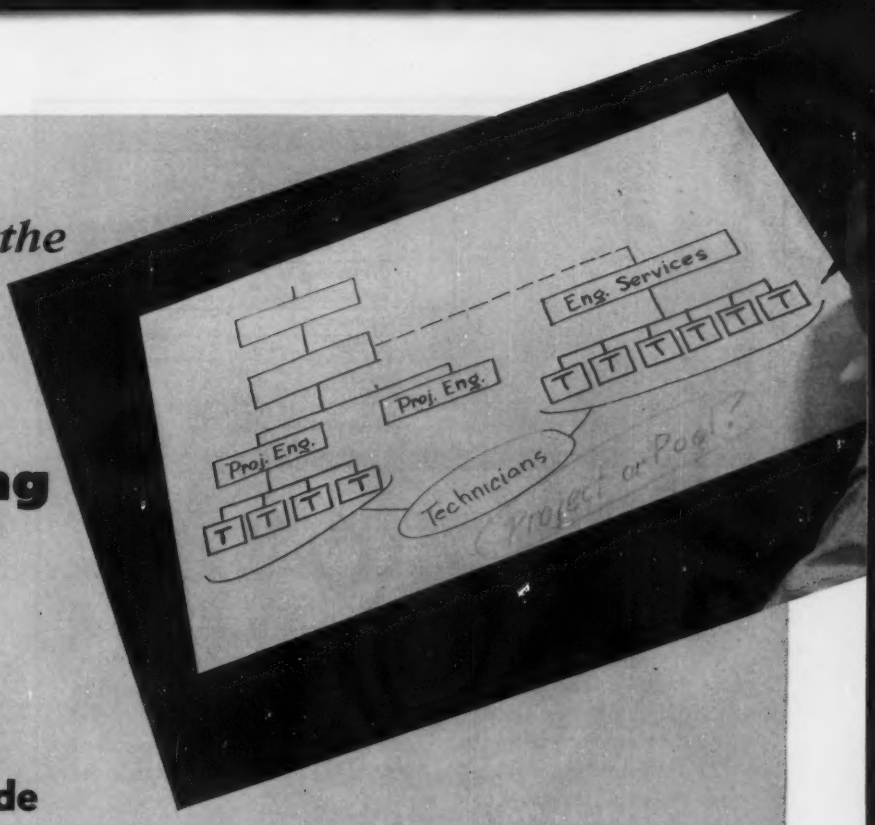
Close-up of the technician:

Engineering Semipro?

3—Managers Can't Decide



JUNIOR engineer, trainee, technical assistant, pair of hands . . . managers view the technician in many different ways. Opinions can't be averaged out, but they usually fall between two extremes: 1. He's a helper going through an early stage in his career, of little real use unless he earns full-engineer status. 2. A pro in his own right, he's a member of a separate group, one related to engineers like orchestra members to composers—competent, but concerned with smaller-scale problems.

This article, outlining management attitudes toward technicians, is third in a series based on a complete report: *Managing Technician Manpower*, available from Technical Manpower Associates, P. O. Box 158, Scarsdale, N. Y.

Advocates of the separate-group notion go along with the views of G. Ross Henninger, director, National Survey of Technical Institute Education:

> • "Technician" is not a dumping-ground category for those who can't make the grade in engineering. As a matter of fact, most of the misfit engineers would be just as miserable if they were engineering technicians.

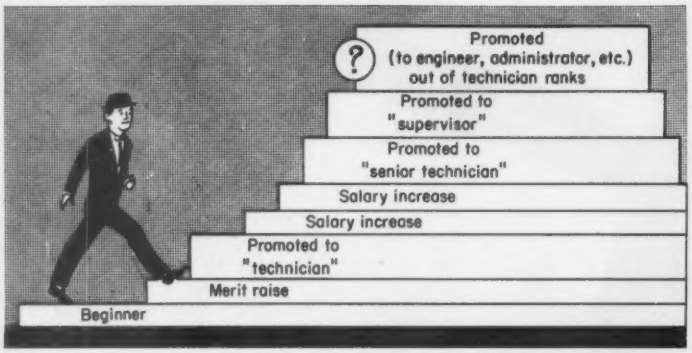
To this, William G. Torpey, of the President's Committee on Scientists and Engineers, adds:

> • Another difficulty is due to considering the technician as an engineer-in-training. Although his normal path for advancement may seem to lie in the engineering classification, in practice, the proper path should be within the framework of his own education and ability.

The Pro Profile

Managers tending to accept the technician recognize his respectable contribution to the technological effort. They don't push him into becoming an engineer, nor do they grant him equal status with engineers. Rather, by classifying him in a group apart, they keep technicians out of engineering ranks. In general sympathetic managers make these concessions to the technician's professional standing:

- He does his best work when given real responsibility.
- Assignments of a professional nature can be adequately handled by a technician team that reports to a senior technician.
- Duties of able technicians should exclude assignments that are strictly manipulative or clerical in nature.
- Engineers need to be trained in how to use a technician more effectively and to understand his proper place on the technological team.
- Technicians are not junior engi-



How Far to the Top?

Technicians have four avenues of advancement in pay grade and responsibility:

▸ Merit wage or salary increases. Most companies make it a policy to review salaries of technical personnel at regular intervals—from every three months to 2½ years, with the average falling between six months and one year. Increases granted range from a nickel an hour to as much as ten per cent of salary. In about 20 per cent of the companies surveyed, merit raises were the only rewards the technician could expect.

▸ Job-classification promotion. Many companies offer titles that reflect promotion in grade to go along with salary increases. Junior technician to technician to senior technician is one example of title changes, but others are also common.

▸ Promotion to supervisor. Three out of every four companies report supervisory positions are open to technicians—usually in production departments. Half the companies use technicians to supervise other technicians.

▸ Promotion to engineer. Any company will consider a technician for an engineering position if he receives a degree from a recognized engineering school. Over half will consider him without the degree if he has demonstrated unusual ability over a long period of time. This promotion is not easy to come by, however. Notions on the limits of technicians and concern for status of the engineer generally close this possibility to all but the very best.

Advice to Managers

Let him know where he stands. Duties of technicians are usually unclear, never having been formalized. To correct this:

- Analyze duties of each engineer and scientist. Determine time spent by each in various phases of his work.
- Find out what parts of the job can be assigned to technicians.
- Point out (to the engineer) how the technician can save him from many detailed jobs.
- Hire qualified technicians.

Provide incentive for technicians by treating the good ones more like pros. Here's what some companies have done:

- Put them on salary, take them off hourly wages.
- Don't make them punch a time clock.
- Don't call them "technicians"—"engineering aides" is better.

neers, but are a group apart. Although good ones can become engineers, respectable and professional advancement may also take place within the framework of the technician group's structure.

The Pair-of-Hands Extreme

The other point of view denies the technician any vestige of professional recognition. It sees the "good" technician as one who leaves the field for the challenge of real engineering. Those content to be left behind amount to "just pairs of hands." Managers favoring this picture of the technician think of him this way:

- He's in training. Effective utilization implies training him to become an engineer. If he can't make the grade he should get into some other line of work.

- Teaming up technicians and engineers is wasteful. Technical-manpower pools, available to all the engineers, reduce the cost of this type of personnel.

- Responsibilities aren't necessary. Even though he may have developed special talents, he's still a technician and needs close supervision.

- His time could be better utilized, but this problem is unimportant relative to the bigger one: That of better utilization of engineers' time.

- He needs only narrow training. Assignments could be rotated to help him develop broader skills, but little would be gained.

Status Depends on the Boss

Personal working relationships between a technician and his supervisor often determine his status. If the supervisor is unquestionably professional (an engineer or scientist), it rubs off on his helpers—at least to some degree. On the other hand, if the technician's job is considered routine (or if he is part of a pool or is bossed by someone of foreman status), he's not likely to establish a free and easy interchange of ideas with the engineers.

One implication of this situation

is quite serious. Educators suggest that management's picture of the technician hinges less upon his abilities than upon impressions left with the engineering staff. To date, they point out, acceptance of the technician by the engineers has been meager.

The educators follow up this argument by claiming rejection of the technician is due to general misunderstanding of his role in the company. They say it can be traced to ignorance (misunderstanding of his form of education and lack of prestige for graduates), carelessness, and selfish fear of loss or compromise of professional position. As C. S. Jones, president, Academy of Aeronautics, puts it:

> • Probably the biggest deterrent has been the attitude of the professional engineer, in many cases unintentional. Frequently, he has considered the technical institute as a trade or vocational school—in many cases a sort of racket trying to sell an artisan as an engineer.

Who Should Supervise?

The technician's supervisor determines his status, but industrial practice reveals a broad spectrum of supervisory patterns. While most companies rely on engineers, senior technicians, and production foremen to oversee technicians' work, three factors distinguish one setup from another: 1. Function of the technician. 2. Organizational structure. 3. Company size.

Function of the technician has direct bearing on who supervises him. In maintenance and testing operations, for example, production foremen do most of the supervising and industrial technicians are assigned to these operations. Their work requires a "feel" for production operations and is actually quite routine. Other technicians work closely with engineers in the development of new designs and products. They are true engineering technicians. Examples all seem to follow the same pattern: Engineering technicians are usually supervised by engineers; industrial technicians work under other kinds of bosses.

Organizational structure determines whether technicians will be pooled or assigned to specific engi-

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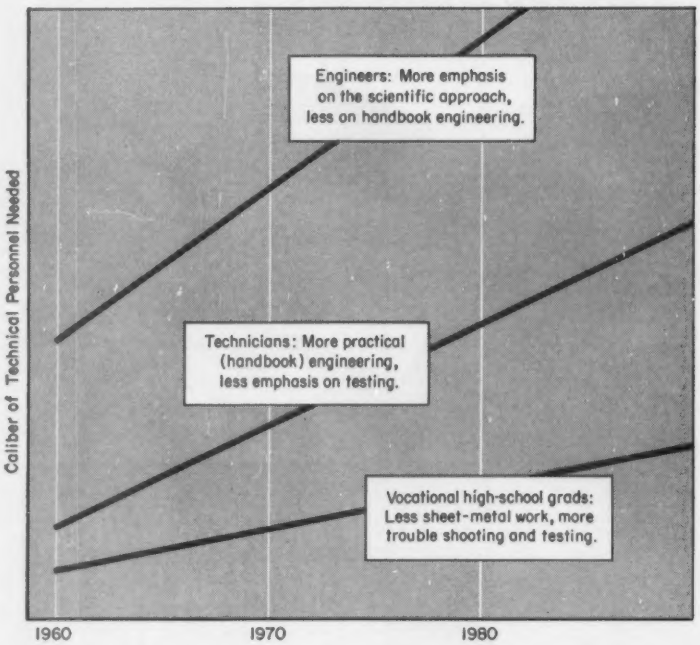

Technical Jobs Are Getting Tougher
Caliber of Technical Personnel Needed
Engineers: More emphasis on the scientific approach, less on handbook engineering.
Technicians: More practical (handbook) engineering, less emphasis on testing.
Vocational high-school grads: Less sheet-metal work, more trouble shooting and testing.
1960
1970
1980

Research advances are opening up new engineering fields so fast that engineers are hard pressed to keep up with developments. In coming years, engineers must take on new tasks. Much of the "shirt-sleeves" engineering will be delegated to technicians, who, in turn, will pass on old duties to vocational high-school graduates. Technical personnel at all levels will be involved in more advanced work.

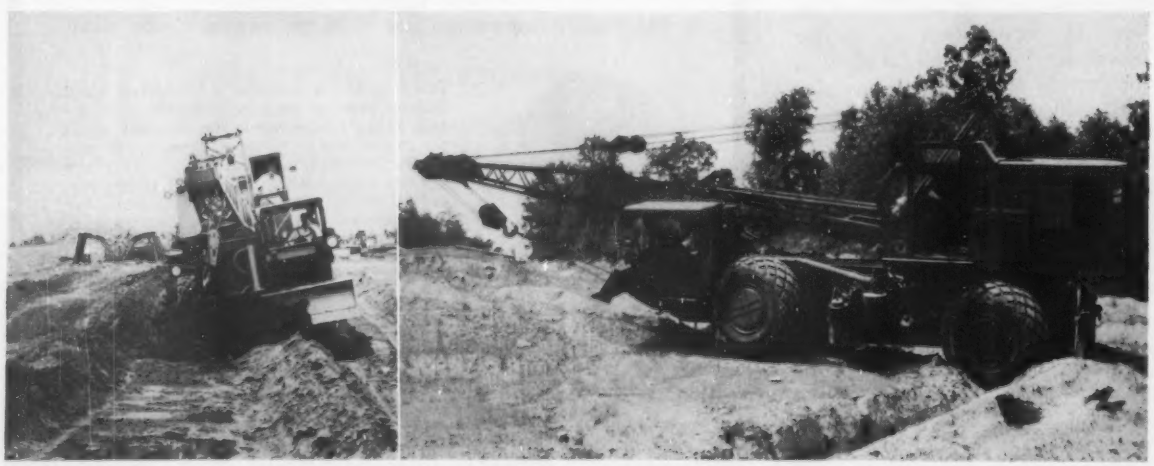
neers. Pooled technicians are generally responsible to both a senior technician and an engineer, and both industrial and engineering technicians can be found in a pool.

Industry is divided on the organizational-structure issue. Some companies feel that the team relationship tends to bog down engineers with administrative details, and that much of the technician's time is wasted if he is tied too closely to one project. On the other hand, many managers stress close relationships between an engineer and a technician. They argue that this bolsters the engineer's confidence in the technician, lets the technician exercise initiative (and make a substantial contribution to the over-all project), and helps the engineer teach and develop a capable assistant.

Size of the company is itself important. The pool type of organization more readily adapts to large companies. Fewer in number in small companies, technicians directly support the professionals, have more opportunity to learn engineering, but are less likely to develop administrative skills and become senior technicians.

Next article in the series, appearing in the June 23, 1960 issue of MACHINE DESIGN, will conclude the series on the technician. It will discuss how management can get good technicians, and, once having them, how to keep them.

Mobile Crane Dozes Own Worksite



Operating without support equipment for sustained periods, a 20-ton capacity crane is being tested by Army engineers. The crane is expected to travel highways at 30 mph, climb 40 per cent grades, and operate in 4 ft of sea water. It is equipped with a 30-ft standard boom, but hydraulic outriggers and counterweights are provided for a 90-ft boom.

Cat's new wheel Traxcavator features fast-working power-shift transmission with Twin Disc Torque Converter

Time was when wheel-type loaders were viewed with scorn as little more than ov[illegible]own agricultural machines. But in the years since World War II, the wheel loader has gained universal favor with construction men. Its speed and mobility have proved to be real production-boosting advantages in many types of loading jobs.

Now, after years of research and engineering plus more than 14,000 machine test hours, the 944 Traxcavator — first wheel loader to bear the famous Caterpillar trademark — has made its appearance.

There's no need to enumerate the 944's many design and performance features. These have been given wide coverage in all the construction magazines. It is worth pointing out, however, that the new wheel loader, like so many other Cat machines, is equipped with a Twin Disc Torque Converter.

The torque converter — a single-stage Type 6 model — works in conjunction with the 944's two-speed forward, two-speed reverse, planetary transmission. Each of these four in-line gear trains has its own clutch. Two of the planetary trains are for direction control while the other two provide gear speed selection. Reverse speeds are 25% faster than forward—a key factor in reducing cycle time. The torque converter assures smooth, instantaneous clutch engagement by absorbing the shock of the shift in its fluid circuit.

Caterpillar is one of many well-known manufacturers who specify Twin Disc Torque Converters for their power-shift transmissions. If plans for a power box are on your drawing board, you'll find the torque converter you need in the complete Twin Disc line. Write our Rockford office for new Bulletin 510.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin. Hydraulic Division: Rockford, Illinois.

TWIN DISC
Torque Converters

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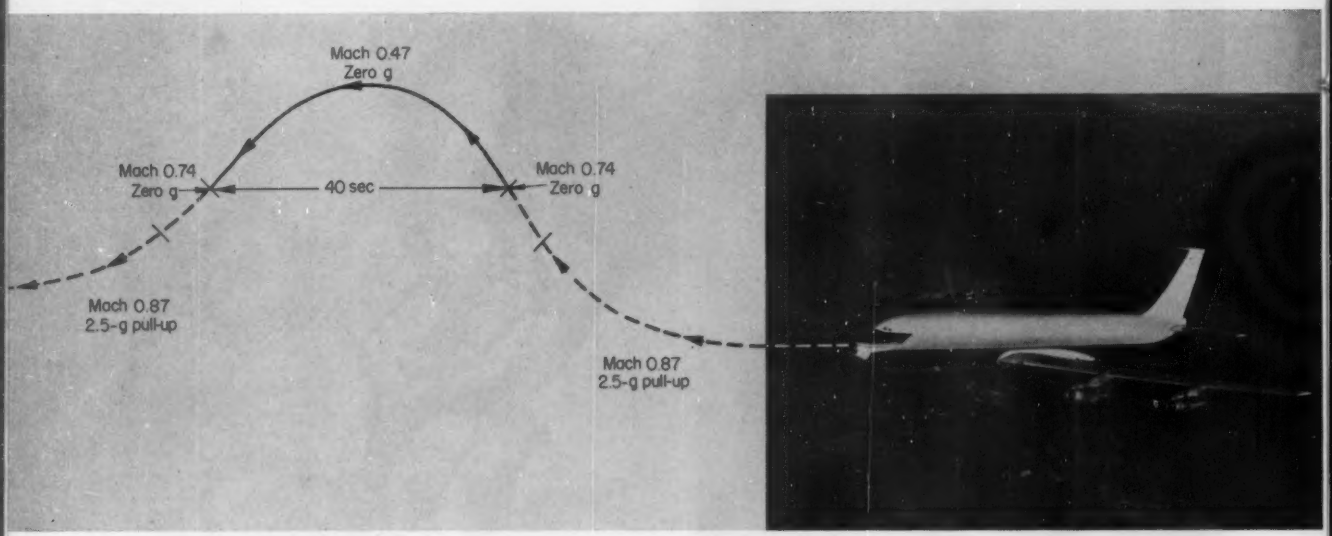


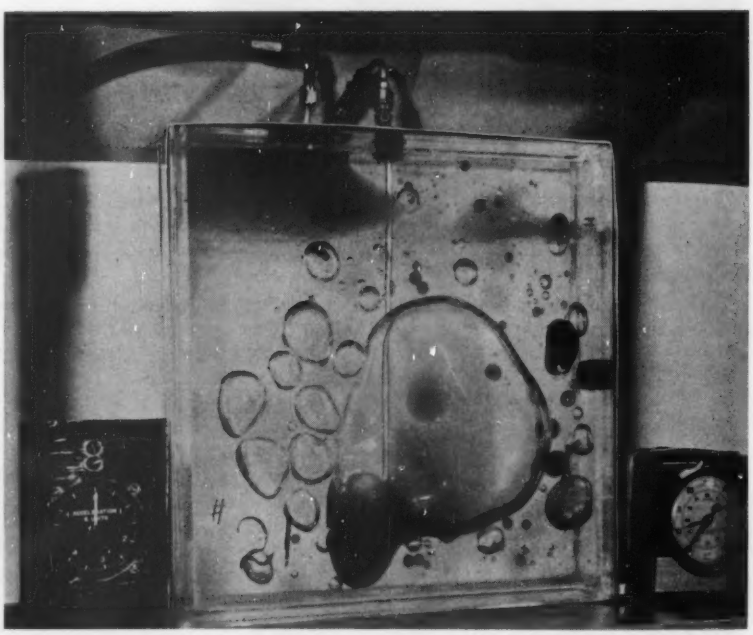
Entering a 50-degree climb, WADD's modified KC-135 jet tanker will maintain crew and equipment in the weightless state for periods up to 40 sec. Pull-up at start and end of the "Keplerian" flight path is held to 2.5 g.

Zero-G Fluid Troubles:

Air Force finds bubbles misbehave, lubes won't feed in weightless state

DAYTON, OHIO — Man's gastro-intestinal system isn't the only "mechanism" that may have trouble adapting to the weightless state in space. Up-and-over flights along zero-gravity trajectories have shown Air Force scientists that fuel and lube systems in spacecraft will also need some help.

First flown in 1958 by Wright Air Development Division pilots, zero-g (Keplerian) flight paths leave an aircraft (and those in it) in a weightless condition for 12 to 15 sec. One of the first equipment problems encountered was a drop in engine oil pressure as the unmodified C-131B aircraft flew over the zero-g trajectory. Tests showed that the weightless oil couldn't be depended upon to orient itself along the bottom of its tank. To get around this, engineers in WADD's Propulsion Laboratory installed a positive-expulsion (pressurized-bladder) system that would insure adequate oil pressure during zero-g



How air bubbles in a fluid behave in the weightless state is shown graphically in this photo. Bubbles either hang suspended, or they move slowly up and down with random motion. They do not merge with each other.

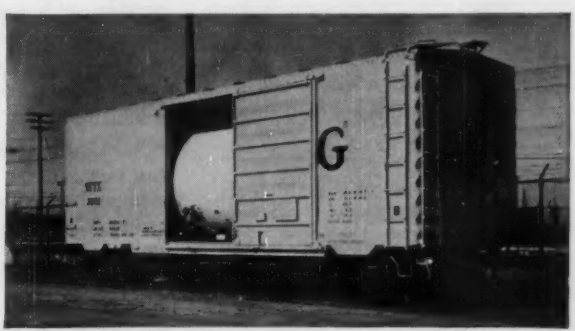
Anaconda Vibration Eliminator, 1½" I.D. x 17", installed in liquid fill line of a 9000-gallon liquid oxygen tank installed in a boxcar by Lox Equipment Co.

When –297°F LOX hits the piping, standard Anaconda tin bronze flexible connectors absorb the shock

Flexible metal hose connections used to absorb thermal contraction and shock in piping carrying liquefied gases vary widely in size, material and design. Anaconda makes assemblies in stainless steel up to 14 inches I.D. for LOX lines in missile ground handling equipment—and other special connectors and hoses in a variety of metals down to ⅛ inch I.D.

But there are many places where standard Anaconda flexible metal hose assemblies of tin bronze can do a job dependably and with economy. Lox Equipment Co., Oakland, Cal., makes unfired pressure vessels to hold liquefied gases. To protect valves and piping from stresses set up when liquid oxygen at –297°F or liquid nitrogen at –320°F begins to flow, the company has found standard Anaconda Vibration Eliminators highly satisfactory. These flexible connectors designed for damping vibration in rigid piping of refrigeration systems have the physical properties needed—the high strength, toughness, and fatigue resistance inherent in tin bronze. In fact, these properties are greater at very low temperatures—tensile and yield strength of copper and copper alloys are materially higher at –300°F than at room temperature. Working pressure of 60 psi is no problem, as standard VE's are designed for applications up to 300 psi—in some sizes up to 500 psi.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are constantly working with design engineers on flexible connectors and hose to meet new problems. They may recommend a standard unit or help in the design of a special unit. For information on standard units or engineering assistance, write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 601220



ANACONDA®
METAL HOSE

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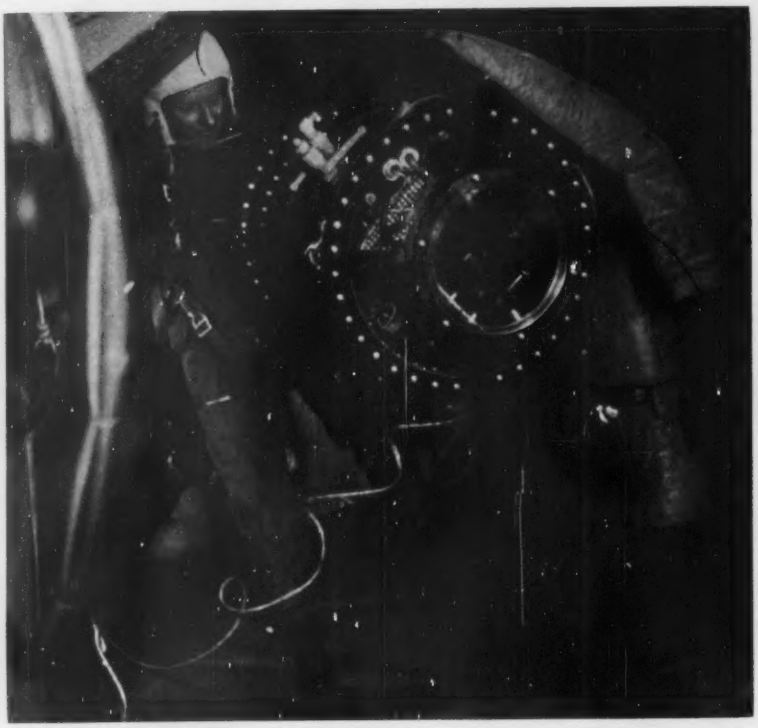
experimental test flights.

Expanding on such first simple experiments, Air Force specialists found that there are more problems than answers in the behavior of fluids exposed to the weightless state. By the fall of 1959, work proposed was more than the C-131B could handle. WADD issued a contract to Boeing Aircraft to modify a KC-135 jet tanker for zero-gravity flights. This aircraft not only gives a larger working space, but also extends the zero-g flight time to nearly 40 sec.



Free-floating capsule contains racks for a number of fluid tanks, plus lights and cameras. When fluid tanks are fastened to the aircraft structure, only 2 or 3 sec of effective weightlessness can be obtained. With the capsule itself floating, the enclosed tanks are weightless for 12 to 15 sec on each parabola. Crewman floats with the capsule to keep it from banging fuselage sides or ceiling.

"Hot" Vinyl Ready for Varied Roles

NEW YORK — A new vinyl plastic that can withstand temperatures 60 degrees higher than conventional vinyls promises a host of new applications for the already versatile material. According to officials of B. F. Goodrich Chemical Co., the new plastic, a polyvinyl dichloride called Hi-Temp Geon, represents the "first significant breakthrough in the industry since the development of the first rigid vinyl 12 years ago."

Geon's main claim to fame is its remarkable strength at high temperatures: Tensile strength exceeds 2000 psi at 212 F, and deformation at 264 psi occurs only at temperatures above 215 F. These properties, coupled with high modulus over a wide temperature range, high impact strength, and toughness, mark the material as a superior thermoplastic.

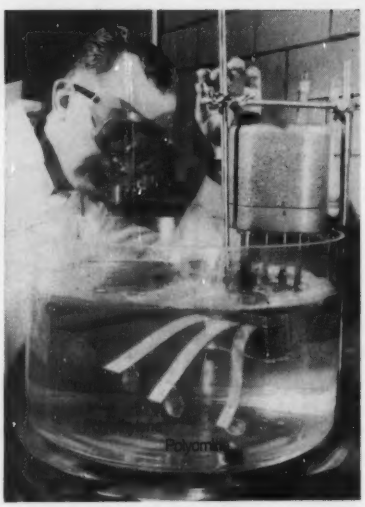
Hi-Temp Geon: Properties

	Normal-Impact Compound	High-Impact Compound
Tensile strength (psi)		
at 73 F	8800	7800
at 212 F	3000	2000
Tensile tangent modulus (psi)	450,000	390,000
Elongation at yield (%)	4.5	4.5
Flexural strength (psi)	17,000	14,500
Izod impact (ft-lb/in. notch)	0.8	5.0
Rockwell hardness R	117	117
Flammability	Self-extinguishing	Self-extinguishing
Heat deformation at 264 psi (F)	220	215
Linear coefficient of expansion (C)	7×10^{-5}	8×10^{-5}

Geon is also distinguished by several other characteristics:

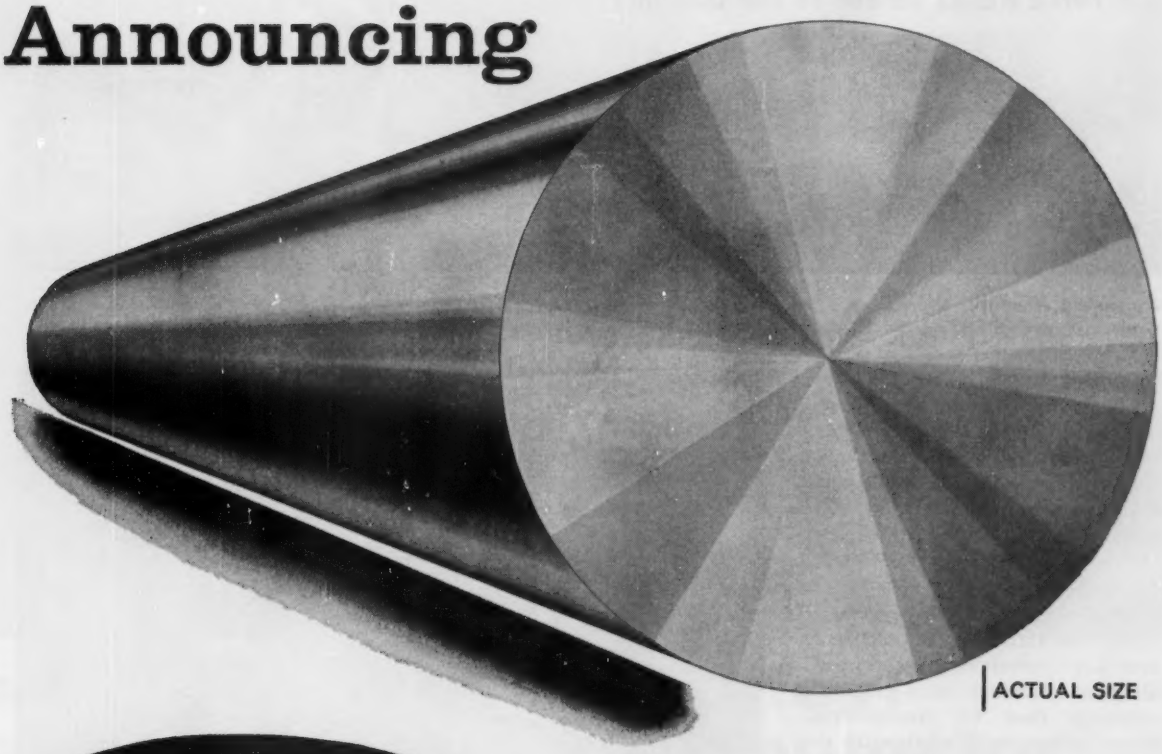
- Fabricated into pipe, it can handle pressures of 100-160 psi at 180 F, with pressure ratings much higher at normal temperatures. Low thermal conductivity of the material reduces moisture condensation on the outside surface of the pipe, keeps liquids "at temperature" inside.
- In actual industrial trials, Geon pipe has carried 98 per cent sulfuric acid at 185 F for 30 days.
- Like conventional vinyl, Geon can be extruded, molded, formed, or stamped on standard plastic-processing equipment. Geon pipe can be joined with socket solvent-cemented joints or threaded couplings, and can be cut by an ordinary saw and formed to desired curvatures by heating.

Although the biggest application foreseen by Goodrich for Geon is in household plumbing (prefabricated walls of bathroom and kitchen piping are under test in several research homes), the material is also expected to be used extensively for other types of piping, tanks, ductwork, and valves. In the automotive field, Goodrich sees Geon hoods and rear decks on future cars.



Soaked in hot water (180 F), Geon doesn't sag like other familiar plastics. The new vinyl also exceeds in a number of other properties.

Announcing



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Air Force Keeps an Ear to the Ground

Channeling effect that takes place close to the surface of the earth will strengthen signals to distant receiving stations. Earlier experiments showed that through-the-earth transmissions were quickly attenuated.

GLENDALE, CALIF.—The Air Force is investigating subsurface electromagnetic radiation as a communications technique. Space Electronics Corp., which did much of the early development, is testing bandwidths, range, atmospheric effects, and a host of other variables to establish an optimum operating system.

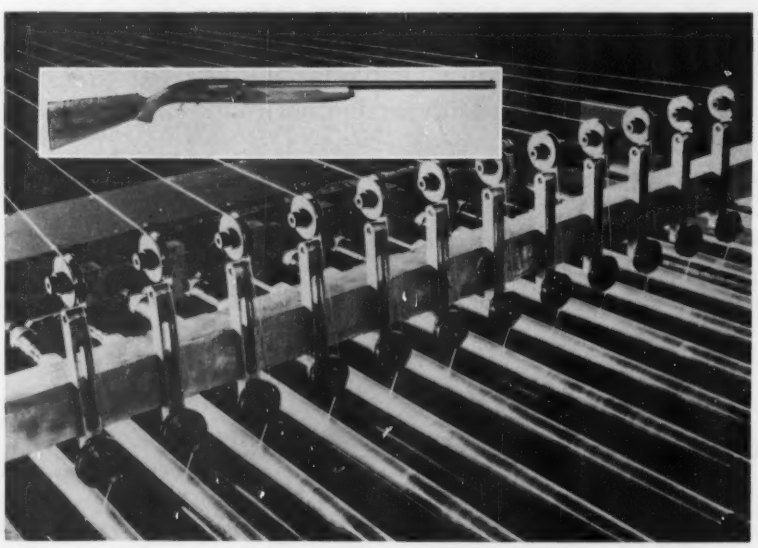
Previously, subsurface communication was considered impracticable over any appreciable distance; SEC disagrees. Although more power is necessary than for conventional, above-surface installations, the requirements remain feasible, and with modern improvements in coding techniques, considerable information can be transmitted in a short time.

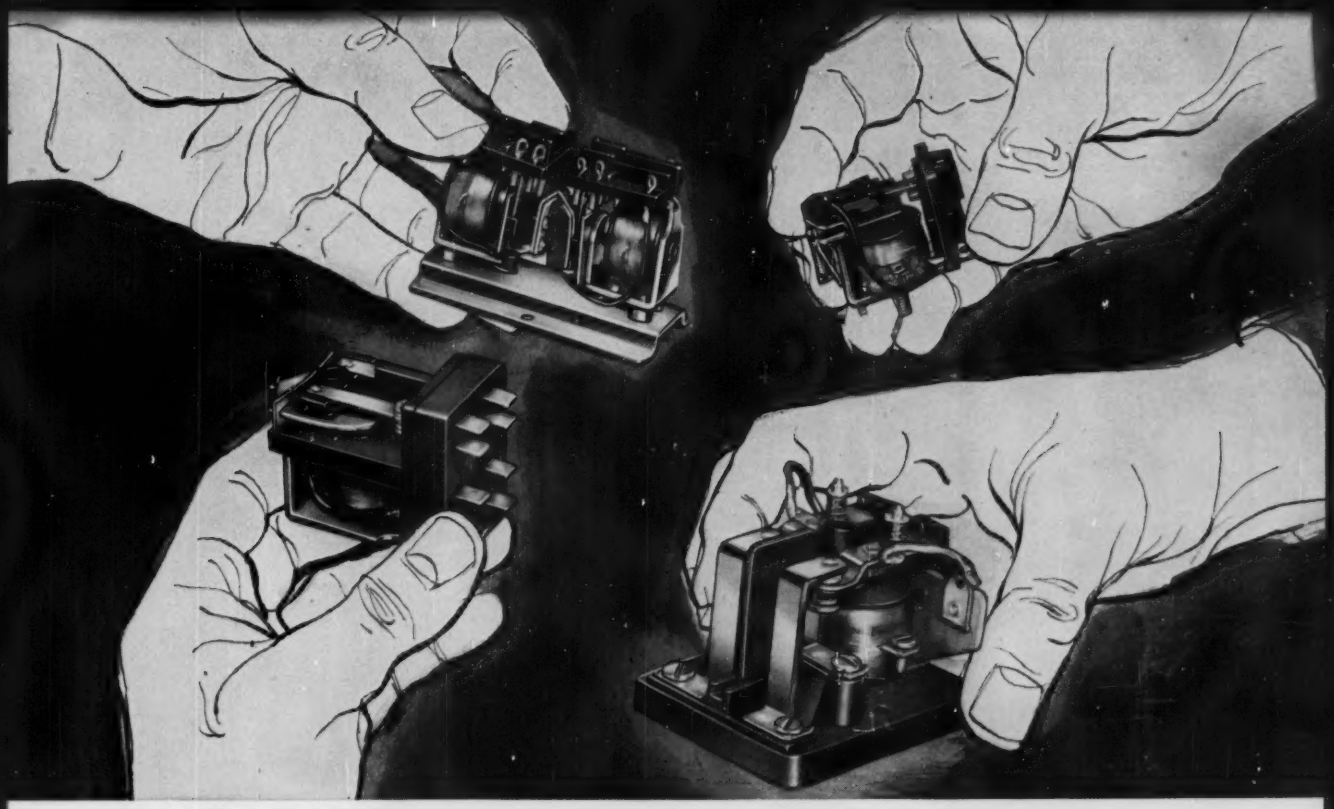
A phenomenon recently uncovered—an energy channeling effect that takes place near the earth's surface—is expected to permit more effective propagation to distant receivers than was previously anticipated. One dilemma the company faces: Whereas low-frequency signals suffer less attenuation than high-frequency signals, the channeling phenomenon benefits the higher frequency signals to a greater extent.

Experimental transmitter, buried deep in a mine shaft in the Mojave desert, aids in research to develop earth currents as an underground communications technique.

Glass Fiber Gets A Shot-Gun Wedding

A glass-fiber barrel is the extraordinary result of research into building a lighter gun. Five hundred miles of glass fiber are wound onto a steel liner only 0.020 in. thick and fused with an epoxy resin. The barrel is twice as strong as steel, yet lighter. Winchester Western Div. claims their 6½ lb Model 59 semiautomatic shotgun (which also has an aluminum receiver) is easier to point than heavier-barreled guns though they point out that it should not be used as a crowbar. Heat-insulating qualities of the barrel mean the hunter will neither burn his hands after rapid firing, nor freeze them in cold weather.





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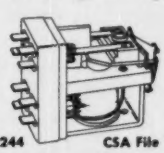
Type	Contact Arrangement*	Type	Contact Arrangement*
PR1AY	SPST-NO	PR5AY	SPDT
PR3AY	SPDT-NO-DM	PR7AY	DPST-NO
		PR11AY	DPDT

These relays are available in any of the following operating voltages: 6, 12, 24, 115, 230 volts 50/60 cycles AC.

Contacts are rated at: 25 amps, 115/230 V. AC 1 phase. 1 hp for 115/230 volt AC motors 1 phase.

*Read: NO normally open, NC normally closed, DB double break, DM double make.

U/L File E22575 CSA File 15734



AB Series

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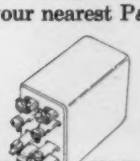
For appliance and general purpose operations requiring long life and quiet operation. Quick connect terminals. Screw terminal adapters also furnished with each relay. Contact arrangement: DPDT. Rated at 10 amps, 115 V., 5 amps, 230 AC non-inductive by U/L and CSA.



ABC Series

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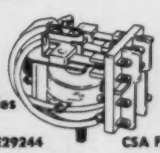
Medium duty power relay in dust cover. For small motors, industrial controls and similar applications. Contact arrangement: DPDT. Rated at 10 amps, 115 V., 5 amps, 230 AC non-inductive by U/L and CSA.



KA Series

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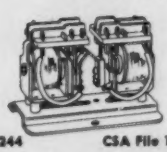
Small, low cost, general purpose relay for handling automation work, small motors, solenoids, other relays. Contact arrangements: SPDT, DPDT and 3PDT. Rated at 5 amps, at 115 V., AC non-inductive by U/L and CSA.



KB Series

U/L File E29244 CSA File 15734

Compact latch relay ideal for memory work and overload applications. Operates on momentary impulse to either coil. Contact arrangements: 4PDT and 6PDT. Rated at 5 amps at 115 V., AC non-inductive by U/L and CSA.

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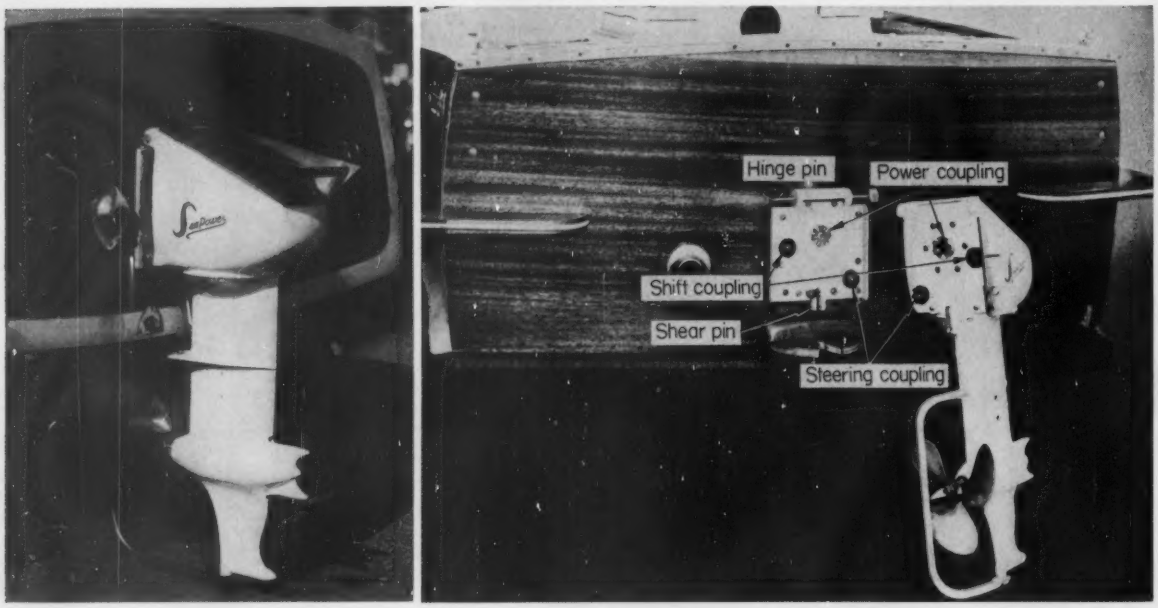
Overboard Goes the Outboard Inboard



Small boat propulsion system, which combines the ease of handling of an outboard motor with the economy and reliability of an inboard, may make a splash in the pleasure boating field. A gearbox, driveshaft, and propeller are combined into a compact 70-lb unit that looks like a 5-hp outboard, and mounts like one. Called the "Seapower outdrive" by its producers, Western Gear Co., Lynwood, Calif., the unit is coupled through the transom to any automotive or marine engine up to 150 hp in size. Hinge and shear pins allow quick release if the outdrive hits an underwater obstacle. Forward-facing "puller" propeller also acts as a rudder, allowing torque-free turns.

Electronic "Wall" Explodes Shells in Flight

Reign of terror of artillery shells may be at an end with the coming of an electronic shell detonator now being tested by the Army. The unit, AN/MLQ-8 countermeasures set, developed by the Electronic Defense Laboratories of Sylvania Electric Products Inc., detonates high-explosive shells in flight. It weighs less than 500 lb, operates unattended, and can be used to protect troops over a wide area. Details of the design have not been released, but it may be presumed that the unit is effective only against proximity-fuse shells.

ECPD Pushes Five-Year Plan

NEW YORK, N. Y.—With an eye to the future, the Engineering Council for Professional Development has been actively pursuing the recent college graduate with a program it calls "The First Five Years." Young engineers are urged to do their share "towards increasing our standard of living, and keeping ahead of Russia through brainpower."

The new graduate, it's pointed out, develops habits in the first year after college which direct his course toward success—or mediocrity. ECPD in 1950 formulated a six point program to cover the first five years in the professional world:

- Career Orientation — Learn the employer's objectives and the relationship of profession to job.
- Continuing Education — Increase technical competence in the light of new business experiences.
- Professional Identification — In-

(*Please turn to Page* 41)

Circle 420 on Page 19→

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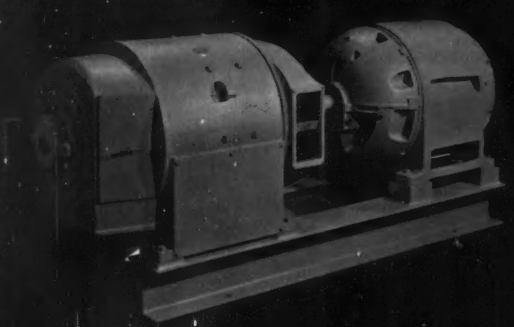
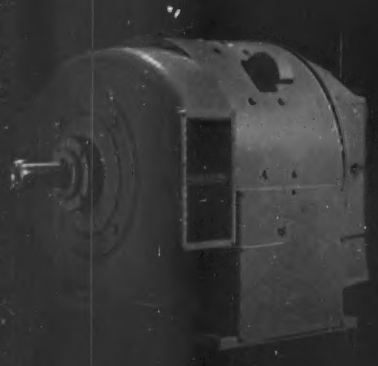


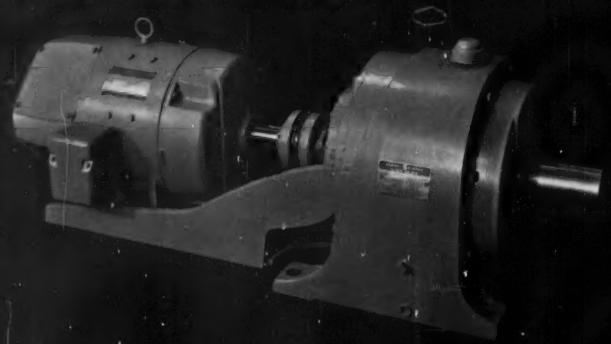
CD-1000 D-C MOTORS

Performance proved. Quality designed. 250 to 1250-hp. Write for Bulletin GEA-5497A*.



ALL-MOTOR GEAR-MOTOR

A-c or d-c. 1 to 75-hp. Simplified maintenance. Produced by Gear Motor & Transmission Components Dept. Write for Bulletin GEA-6704*.



(Continued from Page 36)

crease personal status and benefit from legal qualifications.

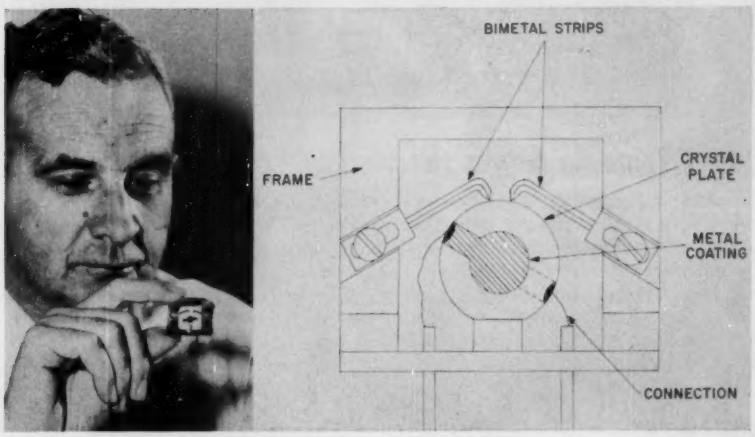
• Responsible Citizenship—Make a place in the community, and in time guide future graduates.

• Selected Reading — Absorb the written experiences of others so as to prepare for dealing with people.

• Personal Appraisal—Be self-critical, thereby eliminating personal shortcomings.

The college graduate is provided with ample opportunity in industry, the Council claims, but the responsibility for professional success rests squarely on his own shoulders.

Simple Pressure Device Keeps Crystal in Tune



Bi-metal strips which vary the pressure applied to a quartz crystal promise more stable frequencies for all kinds of electronic equipment. Dr. E. A. Gerber of the U. S. Army signal research and development Labs, who developed the idea, says they will replace ovens ten times their size in Army radios. The ovens have been used to keep the crystal's temperature constant, but they age the crystals, use valuable power, and are bulky. The bi-metal strips, two or more to a crystal, are entirely mechanical in operation, do not affect the crystal's temperature.

Sperry Award Goes to Gyrocompass Inventor

PHILADELPHIA, PA.—Four of the nation's leading engineering societies recently presented this year's Elmer A. Sperry Award (for outstanding achievement in the field of transportation) to the creator of the Sperry Mk.-19 Gyrocompass. The recipient, Frederick D. Braddon, is chief engineer of Sperry Gyroscope Co.'s Marine Div. Despite the names, the award has never before been presented to a Sperry employee.

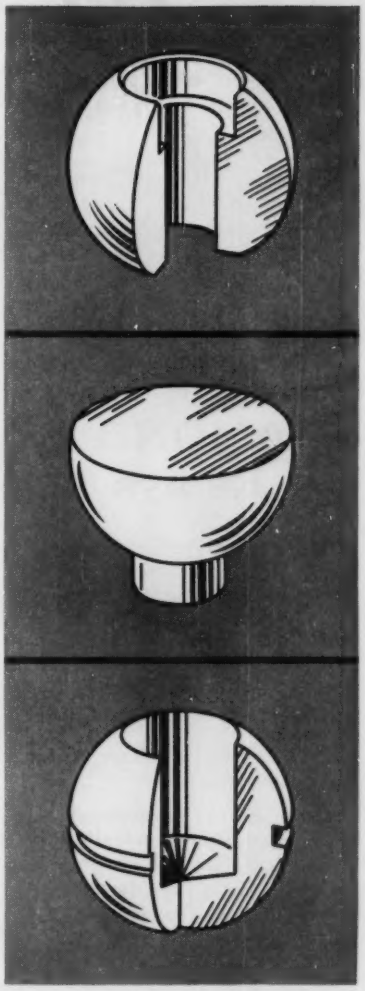
Previous recipients were designers of the *S.S. United States*, the DC series of Douglas Aircraft, the Volkswagen, the GM diesel-electric locomotive, and the British jet, Comet I.

A compass that detects true north by sensing changes in the gravitational forces, the Sperry Mk.-19 has become the basic navigational reference aboard submarines, guided missile cruisers, and other combat ships. Using a highly accurate floated gyro system, it provides directional information and correlates star sights. Accuracy, predicted as two per cent, has in practice been closer to one per cent.

The Sperry Mk.-19 is the heart of SINS (Ships Inertial Navigation System), a highly complex array of gyroscopes, accelerometers, and integrators that guided the submarine *Triton* as it circled the globe under water.

Considered one of the most important developments in the Navy's program of submarine navigation modernization, the gyrocompass is also the predecessor of all concepts of inertial navigation.

MODIFIED BALLS



We make balls with plain or tapped holes, counterbores, slots, grooves, flats, undercuts, stems — in any size — of any workable material — in experimental or production quantities. *If it has a spherical surface, you can count on us to produce it.*

Write for quotation and descriptive literature.

ITI
INDUSTRIAL TECTONICS, Inc.
MANUFACTURERS OF PRECISION BALLS AND BEARINGS
3691 Jackson Road, Ann Arbor, Michigan

Circle 421 on Page 19

←Circle 420 on Page 19

Heart of the Control System

'DIAMOND H' Relays

"Diamond H" relays have a record of high reliability proved in critical applications ranging from missiles to nuclear submarines. That's why increasing numbers of engineers are specifying "Diamond H" relays in the heart of their control systems.

Hart makes these basic types of relays:

- **Miniature, hermetically-sealed aircraft-missile relays, (Series R and Series S).**
- **High-speed sensitive polarized relays (Series P).**
- **General purpose AC/DC relays (Series W)**

Technical literature outlining the wide range of characteristics available in each type relay is yours for the asking. You'll find "Diamond H" engineers skilled in optimizing the basic designs to meet your specific requirements.

Tell us your needs . . . by phone, wire or letter.

THE HART MANUFACTURING COMPANY

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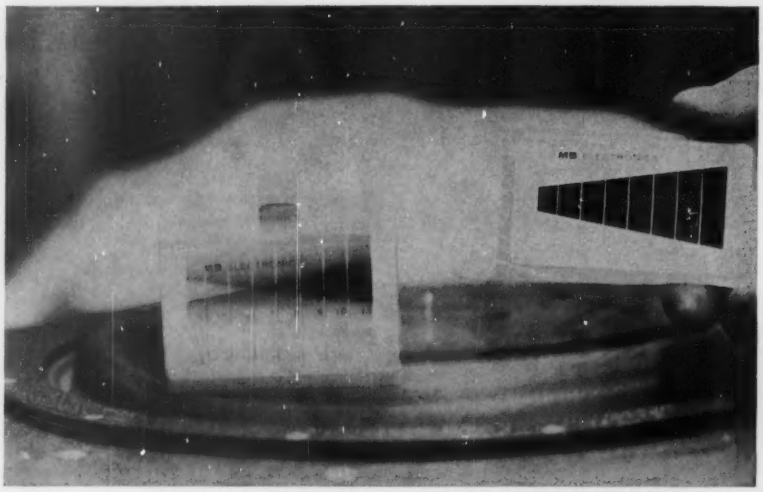
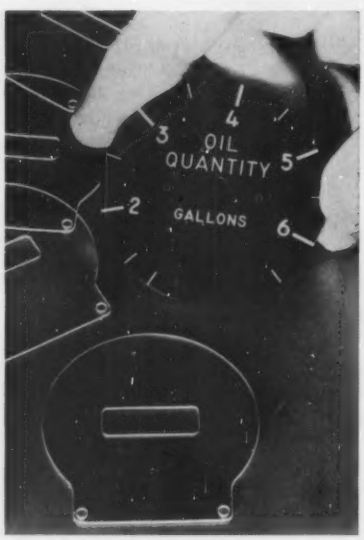


Paper Triangle Gages the Shakes

Vibration displacement is easily measured with an ingenious device that's as simple as a piece of paper. Called an "optical wedge" by its inventors, the gage is a pressure-sensitive wedge-shaped sticker which is affixed to a flat surface on the test piece. (Axis of the wedge is perpendicular to the axis of vibration.) As the piece vibrates, two triangles appear. Displacement is indicated on a scale directly below the point of the darkest triangle. Samples are available from J. C. Stephens, MB Electronics, 781 Whalley Ave., New Haven, Conn.



Dials by Photography

Photosensitive glass that can be precision patterned by chemical machining is being used in making aircraft dials. Corning Glass Works, Bradford, Pa., claims the dials will perform at temperatures that deform other dial materials. Shown above is an experimental dial face of a glass-ceramic, Fotoceram, with numbers and figures permanently placed on the face by a photographic technique developed by an aircraft-instrument manufacturer.

Antiradiation Mechanism Contained in Human Cells

Researchers Pinpoint Chemical Protectors

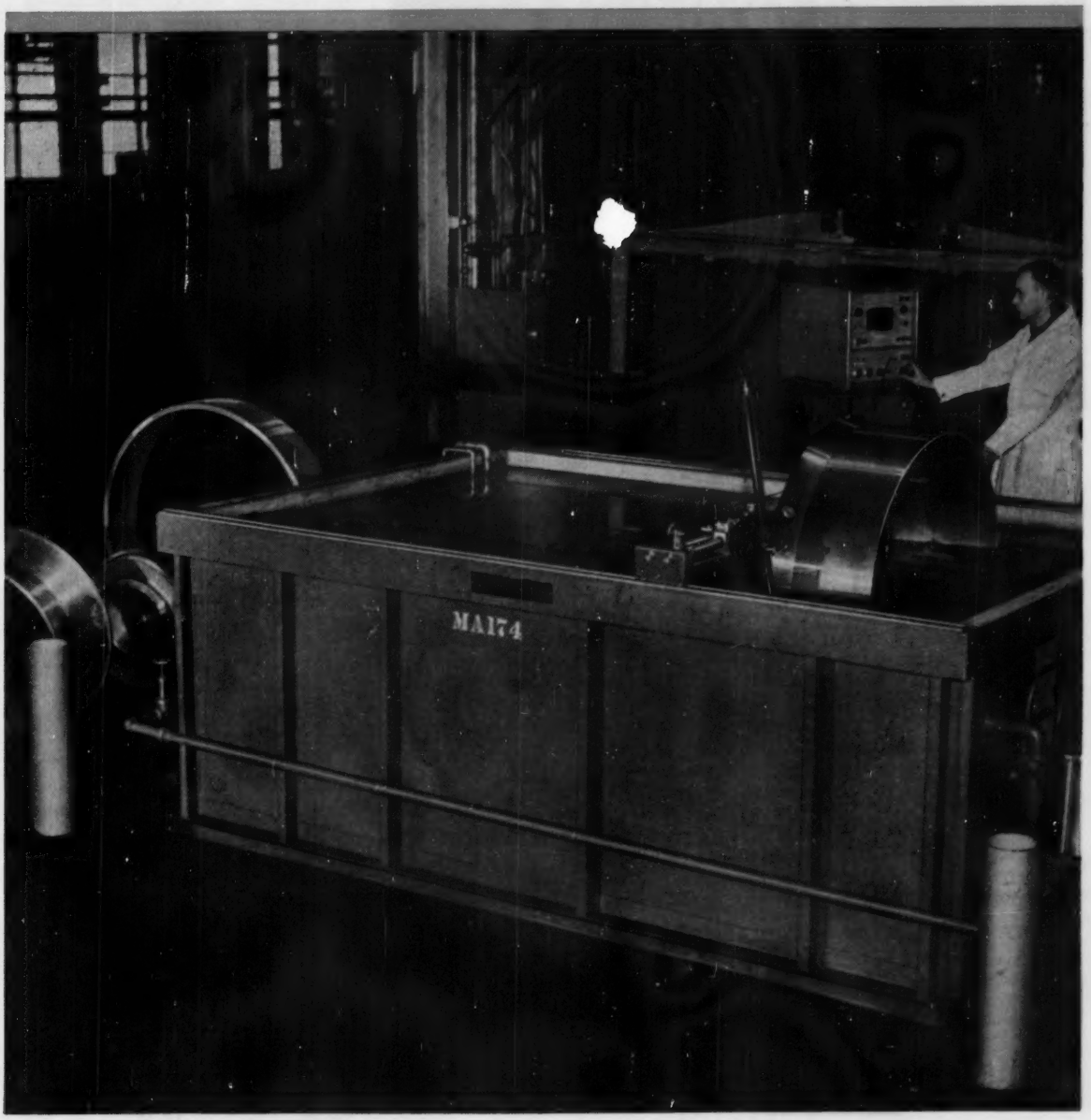
ARGONNE, ILL.—Scientists at Argonne National Laboratory have demonstrated the method by which certain chemical compounds protect living cells against the effects of radiation. The research centered around antiradiation compounds called sulfhydryls (SH), so named because their active group contains sulfur and hydrogen. One of the most effective members of this group in preventing radiation damage in mammals is cysteine, an amino acid present in all protoplasm, the fundamental building block of tissue.

Argonne's research indicates that a combination of oxygen and chemically active molecule fragments team up to cause radiation damage in cells. The molecular fragments, (free radicals), produced by radiation, are pieces of molecules that are highly reactive chemically. They combine with essential components of cells, eventually destroying, or at least damaging, the healthy cell.

Scientists have known for some

Immersion Ultrasonic Testing is the latest addition to Standard's family of extensive quality-control facilities. Specially designed for Standard and one of the first of its kind installed by a specialty steel maker, this new facility is used to detect minute flaws in extremely high quality thin-section and complex-section steel shapes.

It is essential to test for internal flaws in such vital jet and missile engine parts as expander rings, motor case rings, turbine discs, and compressor wheels. Bring your next difficult alloy problem to us—you'll appreciate our personalized service as well as our superior quality control. Write for free illustrated booklet, "Quality Control at Standard."



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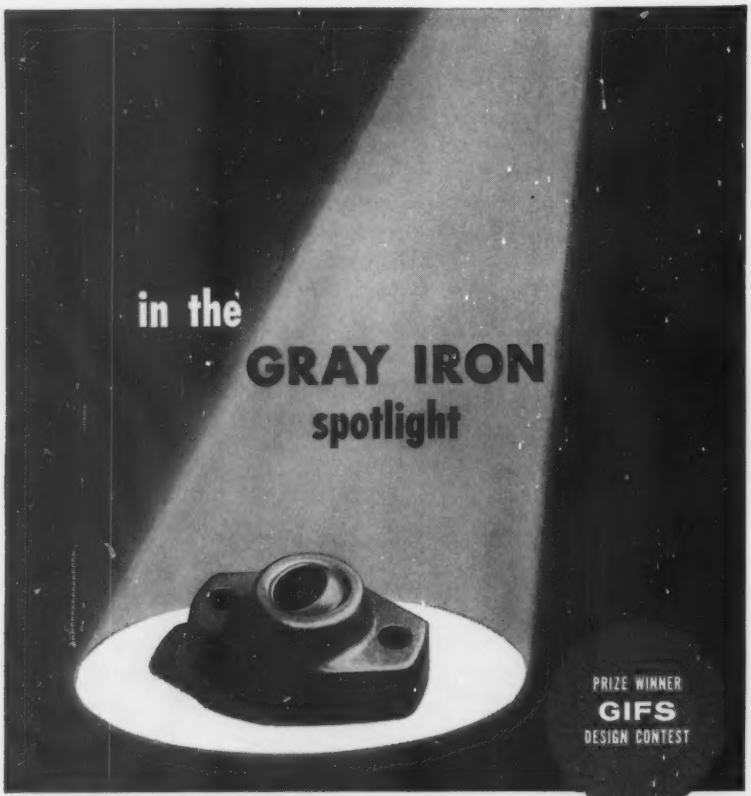

"Ready to go" Gray Iron Casting saves Oliver Corporation 80%

The Oliver Corporation, leading farm implement manufacturer, reduced costs 80% by converting a swivel fastener from a multiple-piece part to a single iron casting. Using gray iron's unique ability to be cast in an intricate shape as one part, *as well as around a movable ball bushing,* Oliver eliminated all assembly and welding operations. The ball is coated with a precise thickness of refractory so that when the iron is cast around it and the refractory removed, the ball is firmly held but free to move. You, too, can eliminate costly in-plant operations. Design your products "ready to go" with your GIFS foundry engineer. Through association with nearly 400 foundries, he has acquired a broad fund of knowledge to help improve your product.

FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.

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time that the presence of oxygen in living systems increases the sensitivity of the cells to radiation. However, they did not know the nature of this effect, nor did they have any clear evidence of a link between oxygen and the action of protective compounds.

Researchers have usually proposed that SH compounds work by consuming oxygen in the system, thereby reducing the concentration of oxygen and reducing radiation sensitivity.

Argonne's work proves that SH compounds also function by removing free radicals, which, in the presence of oxygen, would be toxic.

According to Dr. Edward L. Powers, leader of the microbiology group in Argonne's Division of Biological and Medical Research, "Our work has been principally with dry bacterial spores because of experimental accuracy and convenience. However, the results are certain to give more insight into the results observed in living wet cells. They constitute a basis for the methodical analysis of the importance of these factors in radiation damage in higher organisms, including man."

Meetings and Shows

June 19-24—

American Institute of Electrical Engineers. Summer General Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

June 20-22—

American Society of Mechanical Engineers. Applied Mechanics Conference to be held at Pennsylvania State University, University Park, Pa. Additional information can be obtained from ASME, 29 W. 39th St., New York 18, N. Y.

June 20-24—

American Society for Engineering Education. 68th Annual Convention to be held at Purdue Univer-

sity, Lafayette, Ind. Further information is available from W. Leighton Collins, University of Illinois, Urbana, Ill.

June 26-July 1—

American Society for Testing Materials. Annual Meeting and Exhibit to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Additional information can be obtained from ASTM headquarters, 1916 Race St., Philadelphia 3, Pa.

June 27-30—

Institute of the Aeronautical Sciences. National Summer Meeting to be held at the Ambassador Hotel, Los Angeles. Further information is available from IAS, 2 E. 64th St., New York 21, N. Y.

Aug. 8-12—

American Institute of Electrical Engineers. Pacific General Meeting to be held at the El Cortes Hotel, San Diego, Calif. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Aug. 16-19—

Society of Automotive Engineers Inc. National West Coast Meeting to be held at the Jack Tar Hotel, San Francisco. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Aug. 23-26—

Western Electronic Show and Convention to be held in the Memorial Sports Arena, Los Angeles. Sponsors are the Western Electronic Manufacturers Association and the Institute of Radio Engineers. Additional information is available from Wescon headquarters, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Sept. 6-16—

Production Engineering Show to be held at the Navy Pier, Chicago. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-16—

National Machine Tool Builders Association. Machine Tool Expo-

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Need a special motor? Our knowledge may aid in reducing the engineering time. We are the exclusive supplier to many manufacturers for motors with unusual operating conditions and duty requirements. Write us your needs!

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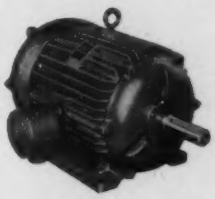
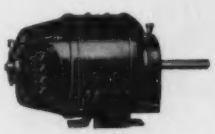


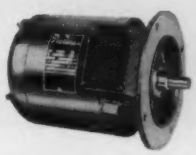
TEPC and EXPLOSION-PROOF

External fan draws cool air across motor toward driven machine.



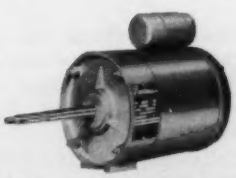
DIRECT CURRENT

High starting torque, good overload capacity and high electrical efficiency. For rough usage.



WEATHER-TIGHT SPECIAL FLANGE

EXPLOSION-PROOF TORQUE MOTOR WITH BRAKE



SPECIAL FLANGE REVERSING HOIST MOTOR, SINGLE PHASE

ENGINEERING DATA: Special mountings. Various modifications—special shaft features; paint and varnish treatments, Class A, B, F, H insulation. Peerless builds to standards and specifications of JIC, AIEE (including AIEE No. 45 Marine Duty), ABS, Federal and Military.

WRITE FOR BULLETINS: Space-Saver, SP-1; Torque, T-1; Complete Line, SDA-155. *Peerless Electric Division, H. K. Porter Company, Inc., W. Market Street, Warren, Ohio.*

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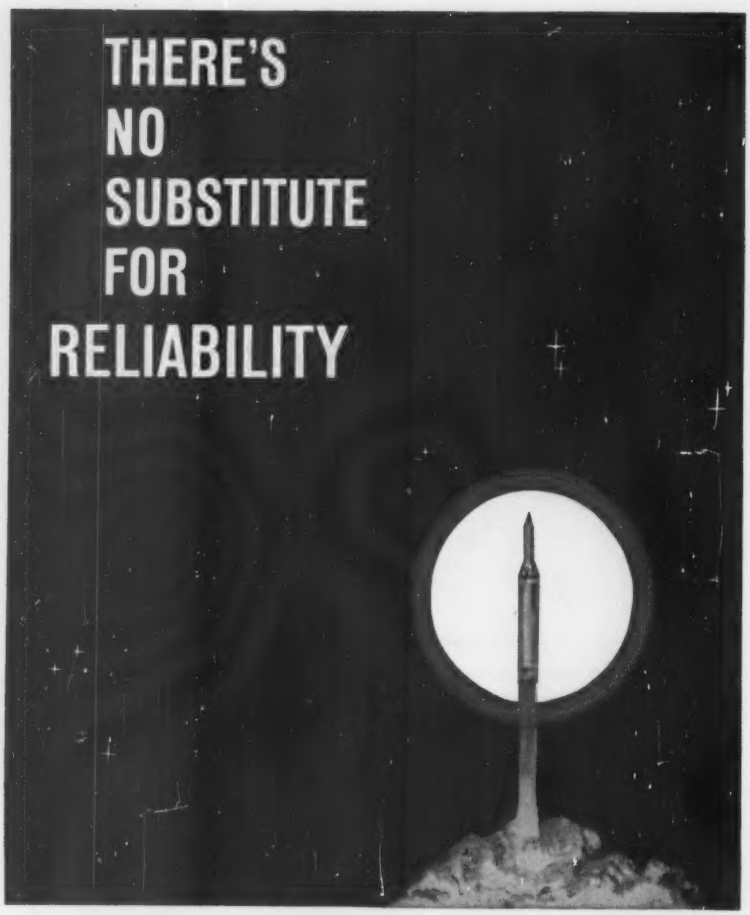

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sition to be held at the International Amphitheatre, Chicago. Additional information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 7-9—

American Society of Mechanical Engineers. Joint Automatic Control Conference to be held at Massachusetts Institute of Technology, Cambridge, Mass. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Short Courses and Symposia

June 20-July 1; July 5-15—

Recent Developments in Electrical Engineering sessions to be held at the University of Pennsylvania. Developments made in the last five to ten years in three fields will be covered by these programs: Modern Radar Techniques (June 20-July 1); New Devices for Amplification and Switching (June 20-July 1); and Numerical Analysis for Digital Computers (July 5-15). Further information can be obtained from Special Summer Session Office, The Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Pa.

July 7-8—

Seminar on Low-Cost Automation to be held at Pennsylvania State University will cover use of pneumatic control in industry, development of a hydraulic circuit for automating a machine, application of relays for automation, static switching systems, state of the art in small U. S. industries, and applications in European industry. Additional information can be obtained from the Conference Center, The Pennsylvania State University, University Park, Pa.

July 11-15—

Institute in Technical and Industrial Communications to be held at Colorado State University. Purpose is to provide counseling and basic and advanced instruction in technical writing and related communications. Additional information is

Circle 426 on Page 19

available from the director of the Institute, Colorado State University, Fort Collins, Colo.

July 18-22—

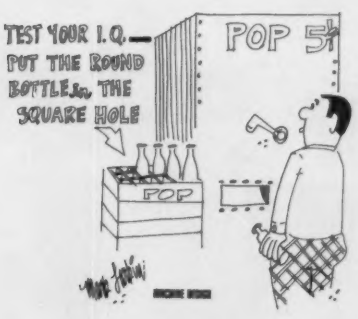
Survey course on radioisotope principles and techniques, designed to increase management understanding of basic concepts, to be held at the University of California at Berkeley, with the co-operation of the U. S. Atomic Energy Commission. Further information can be obtained from the Engineering and Sciences Extension, University of California, 2451 Bancroft Way, Berkeley 4, Calif.

July 24-29—

Research and Development Management Development Seminar, to help middle management representatives develop skills in administration and human relations, to be held at Pennsylvania State University. Additional information can be obtained from the Continuing Education Conference Center, The Pennsylvania State University, University Park, Pa.

Aug. 1-19—

1960 Statistical Methods in Industry Program, including courses in quality control by statistical methods and in industrial reliability to be held at the University of California. Fifteen-day courses in design and analysis of industrial experiments and in basic measurements and standards (including nondestructive testing) will also be offered. Additional information can be obtained from Prof. Edward Coleman, Department of Engineering, University of California, Los Angeles 24, Calif.



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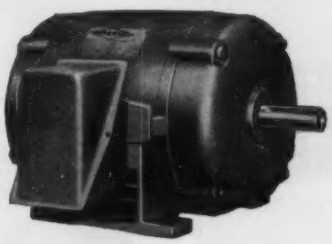

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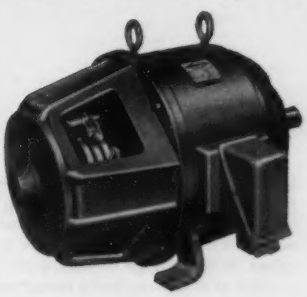

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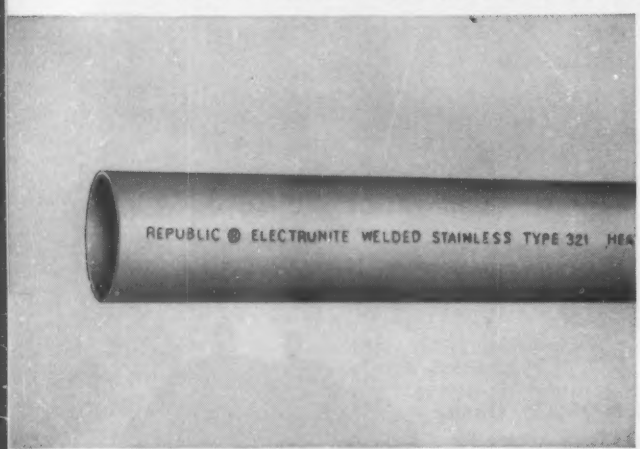
Grumman Aircraft Engineering...
SAVES TAXPAYER DOLLARS WITH REPUBLIC ELECTRUNITE STAINLESS STEEL TUBING

Grumman Aircraft Engineering Corporation has substantially reduced production costs of the exhaust system used in the Grumman S2F Tracker, through the use of Republic ELECTRUNITE Stainless Steel Tubing.

Since using ELECTRUNITE, Grumman has reduced scrap loss by 50%. Fabrication time is 30% less, with further savings through longer tool wear.

ELECTRUNITE® Stainless Steel and Carbon Steel Tubing is available in a wide range of sizes, gages, wall thicknesses, to meet practically any national security, manufacturing, fabricating, and pressure tubing application. Call your Republic representative for complete information and specifications. Or, write direct.

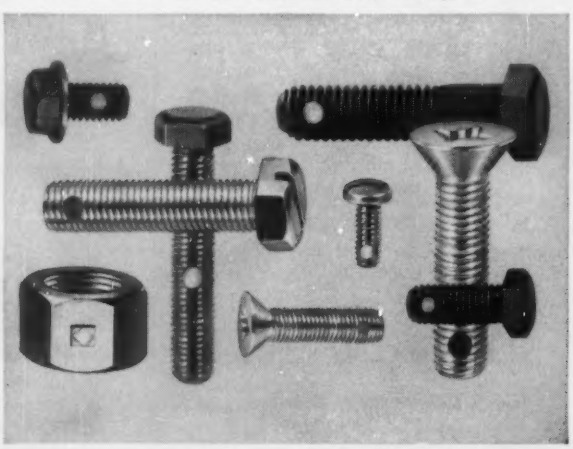
Republic ELECTRUNITE Stainless Steel Tubing, Type 321, is used in the exhaust system of the Grumman S2F Tracker, saving taxpayer dollars. ELECTRUNITE can save money for you, too. *Circle 428 on Page 19*



Further savings are realized through Republic's Steel and Tubes Division manufacturing facilities of bending, forming, welding operations. Write for information. *Circle 429 on Page 19*

REPUBLIC HS6460 HIGH STRENGTH POWDER can be used to produce comparable strength structural parts at lower manufacturing costs than obtainable with copper infiltration. Additional production economies can be achieved because fewer operations will be required to obtain high density, higher strength parts. HS6460 is capable of a minimum tensile strength of 60,000 psi at 6.4 density —100,000 psi after heat treatment. Write today. *Circle 430 on Page 19*

REPUBLIC NYLOK® SELF-LOCKING FASTENERS provide a single-unit answer to vibration, shock, and tension. A permanent nylon insert forces mating threads together for maximum holding power in any postion. The relatively inert nylon resists age and moisture; its natural resiliency permits easy adjustment and repeated use. Republic NYLOK Fasteners are non-galling and require no lubricants. Send coupon for descriptive literature; specify bolts or nuts, or both. Use the convenient coupon, below. *Circle 431 on Page 19*



GRUMMAN S2F TRACKER—first airplane specifically designed to detect, identify, track, and destroy enemy submarines. The Tracker utilizes radar, sonobouys, and Magnetic Airborne Detector gear to pinpoint the enemy, then chooses either torpedo, depth charges, or rockets to effect the kill.

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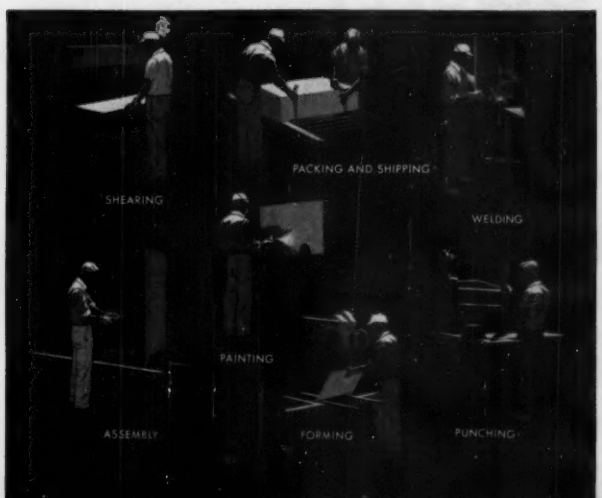

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It's more than a desire to serve. It's the proven ability to serve you as an OEM. At Allis-Chalmers, we want your components business. We'll work to get it and we'll work to keep it. **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin.* A-1340

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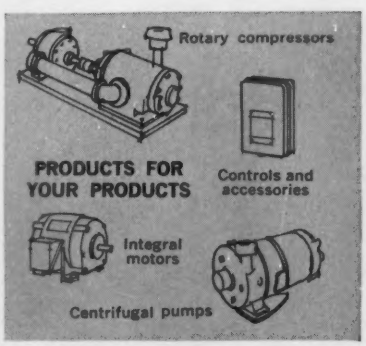
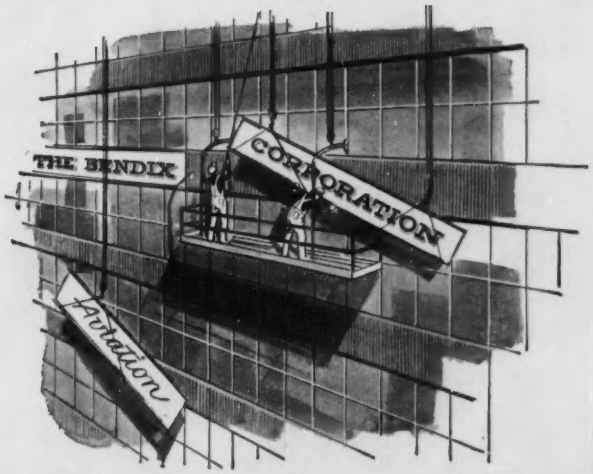


Circle 434 on Page 19

After 31 years of continuous growth and diversification as Bendix Aviation Corporation . . .

We've changed our name to

The Bendix Corporation



To reflect our dynamic growth in such fields as electronics, missiles and space, automotive, weapons systems, computers, machine tools, instrumentation, nuclear technology, hydraulics, meteorology, electrical, marine and others, we dropped "Aviation" from our corporate name on June 1, 1960. We do not wish to convey the impression that our products and skills are limited to the aviation field alone, although aviation products accounted for billings of $388,700,000 in 1959.

Today Bendix®—through 25 divisions and 16 subsidiary and affiliate companies around the world—serves many fields.

Our success in the rapidly expanding age of aviation has long obscured the fact that the Bendix automobile starter drive was the company's first major product. Bendix introduced the type of four-wheel brakes that over the years has been used on most makes of cars. Bendix also pioneered automotive power brakes and power steering. Our automotive business in 1959 totaled $114,300,000.

A notable trend in Bendix' recent history is the utilization of electronics in many of our major fields of activity. These range from automobile radios to aircraft and industrial communications and automatic flight controls . . . from electronic computers and data processing to numerical tape control systems for machine tools . . . and from transistors and ship-to-shore telephones to sonic cleaning and undersea sonar detection equipment. Approximately 40% of Bendix products are electronic, including air defense radar which today guards 25 million square miles.

Missile and space equipment accounted for $103,000,000 of our total business of $689,692,312 in 1959. In addition to being the prime contractor for two important missiles, Talos and Eagle, we are also a supplier of components and sub-systems for most U. S. missiles. Bendix is likewise taking an active part in Project Mercury and in satellite communications. The first is the program to put a man into space. The second will mark a new era in communications by using a satellite in orbit as a relay station for global radio messages.

Bendix also has a growing and diversified nuclear program. Since 1949 we have operated the Kansas City Division for the Atomic Energy Commission. It is a large manufacturing organization employing 7,500 people engaged in the atomic weapons program. We also supplied control mechanisms for nuclear submarines and nuclear industrial power plants, and we are playing a part in developing the newest U. S. atomic power plants for aircraft, missiles and space vehicles.

Thus, as we drop "Aviation" from our corporate name, but not from our programs, we face a tomorrow where the range of our opportunities is broadening at a breathtaking rate.

A thousand <u>*diversified*</u> *products*

THE Bendix CORPORATION
Fisher Bldg., Detroit 2, Mich.

Circle 435 on Page 19

bend, stamp, cut,
and form away!
this handsome pre-finish
stays put

VINYL-ON-METAL is cooperative. Stamp it out. Punch it out. Even weld it! Form it the same ways you form unfinished sheets. The unique colors, textures and patterns of Vinyl-on-Metal sheeting or coils remain unaffected. The tough resilient surface stays—won't chip or peel in use. It protects against tearing or wrinkling—minimizes surface damage during fabrication and assembly. Vinyl-on-Metal is already widely and successfully used for furniture appliances, transportation interiors, building construction, and in many other fields. For a highly informative booklet, "Vinyl-on-Metal," write to Monsanto Chemical Company, Plastics Division, Room 753, Springfield 2, Mass.

Monsanto developed and today supplies Opalon® and Ultron® vinyls for superior finishes on steel, aluminum, and other metals, and on wood, paper and glass.

MONSANTO DEVELOPER IN **PLASTICS**

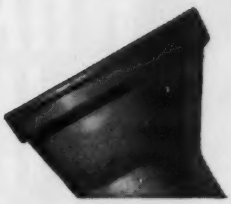
Monsanto

Circle 436 on Page 19

®

FOR THE MACHINERY PART

THAT TAKES THE BEATING



HAYNES Alloys *will do the job!*

Perfect performance for 100,000 hours at orange heat, in the combustion chambers of diesel engines, is quite an achievement. Yet it's the record of tens of thousands of special combustion cups of HASTELLOY alloy C in a well-known line of diesels.

The alloy was chosen for its unique high-temperature strength and corrosion resistance and its outstanding ability to hold heat.

These and other special properties are built into HAYNES alloys —to fit the particular needs of design and production engineers for machinery parts that must meet the roughest service conditions.

If you are designing such a part, investigate HAYNES alloys. There are more than 15 to choose from. They include HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

HAYNES ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 30 East 42nd Street, New York 17, N. Y.

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY PARTS THAT RESIST...

ABRASION. Ten times the life and still no sign of wear, is the record of this plastics-extrusion torpedo nose made of HAYNES STELLITE alloy No. 3. This is one of many HAYNES wear-resistant alloys.

CORROSION. Baskets made of HASTELLOY alloy C used for holding forgings during acid treatment, are still good after 15 months of service. Materials formerly used were replaced every month.

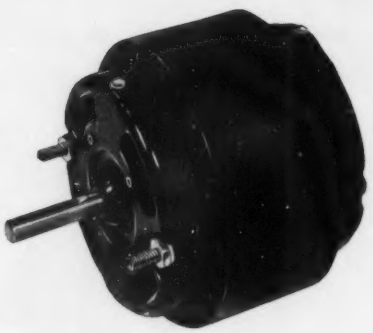
HIGH TEMPERATURE. Turbine wheels in the "hot" ends of diesel engine turbochargers are investment-cast of HAYNES STELLITE alloy No. 31, for service at speeds up to 50,000 rpm. at 1500 deg. F.

Circle 437 on Page 19

CONSTANT SPEED AND TORQUE OF **EMERSON ELECTRIC MOTORS**

is assured by balanced Die-Cast Rotors

The precision tolerances of the rotors in Emerson Electric Motors insure a uniform air gap for constant speed and torque. Noise and vibration are kept to a minimum by the symmetrical rotor design that provides a porous-free casting. The rotor is supported on each side to decrease the bearing load and give your application long, trouble-free operation.



EMERSON ELECTRIC MOTORS are custom engineered to suit your specific needs. Call us *today*—you'll like our way of doing business!

EMERSON ELECTRIC *of St. Louis • Since 1890*

DEPT. M14, 8100 FLORISSANT • ST. LOUIS 36, MO. • CO 1-1800

Circle 438 on Page 19

Circle 439 on Page 19→

116 reasons why we can help you put your finger on the right plastic faster

85 PHENOLITE® laminates...

3 different thermoplastics...

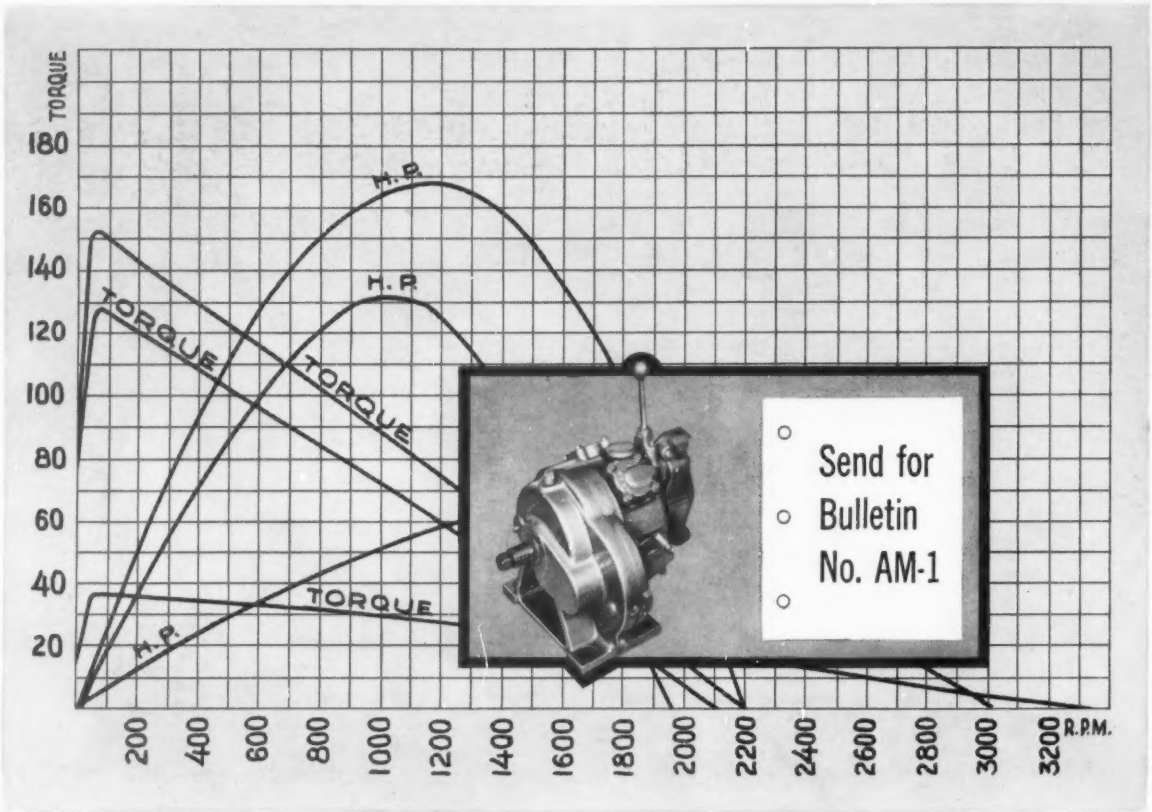
16 grades of Vulcanized Fibre...

12 grades for printed circuits...

This will give you an idea of how surely National can help you pinpoint exactly the plastic you want. National has the broadest line in the industry, including standard forms, precision-fabricated parts, and a huge stock of many grades ready for immediate shipment. For fast help, samples, or more information, contact your nearby NVF sales office. You'll find the 'phone number in Sweet's Product Design File 2b/Na. Or write NVF, Dept. TT, Wilmington, Del. It's a direct line to the one best material per dollar of design performance.

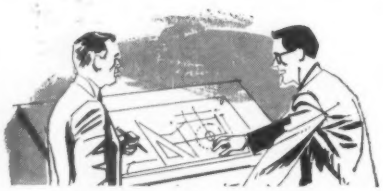
NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

In Canada:
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario



Typical torque and horsepower curves for three sizes of Gardner-Denver 5-cylinder radial air motors.

Power curve proves high starting torque of this radial air motor



IN INDUSTRY—SPEEDING THE PACE,

the Gardner-Denver specialist is an integral part of the team. He works side by side with engineers and designers, helping to solve their problems, for at Gardner-Denver there's no substitute for men—our 100-year philosophy of growth.

Here's a compact *air* power package that develops high starting torque and maintains smooth power under all speed and load conditions. Gardner-Denver's 5-cylinder radial design provides accurate counterbalancing and overlapping power impulses. At least two cylinders are always on the power stroke and three during part of the cycle. Heavy loads start easily . . . accelerate smoothly.

This Gardner-Denver air motor also offers control flexibility, vibrationless operation, high torque at any speed, freedom from overload damage and spark-free operation.

There are six Gardner-Denver radial air motors from which to choose, with power and speeds for a wide variety of applications. Sizes from 2 to 16 hp. Direct drive or built-in gear reduction. Reversible and non-reversible models. Put air power to work in your design. Contact your nearby Gardner-Denver representative for complete information.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

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ANOTHER NEW PRODUCT OF

C/R

BULLETIN SS-100

SCOTSEAL*

A new concept in oil seal design!

Integral sealing surface prevents major causes of leakage

It is now generally recognized that major causes of leakage among shaft type oil seals are: improper handling before assembly, damage by the assembler or shaft during installation, and improper shaft finish. Experts say surface finish of from 5 to 15 microinches is most desirable —but this is often prohibitively expensive.

The C/R SCOTSEAL precludes any possibility of damage by handling, installation, or shaft finish because the *sealing lip does not touch the shaft!* C/R's development of SCOTSEAL's integral, self-contained sealing surfaces assures you of reliable performance unsurpassed by the finest machined shaft surfaces.

HIGH PERFORMANCE OPERATION

Field tests have shown that this new C/R SCOTSEAL:

- **SEALS WITH GREATER EFFICIENCY**
- **RUNS COOLER WITH LESS FRICTION**
- **DELIVERS GREATLY INCREASED SERVICE LIFE**
- **ELIMINATES SHAFT SCORING**
- **PREVENTS SEAL LIP DAMAGE AT ASSEMBLY**
- **REDUCES ASSEMBLY AND REPLACEMENT COSTS**

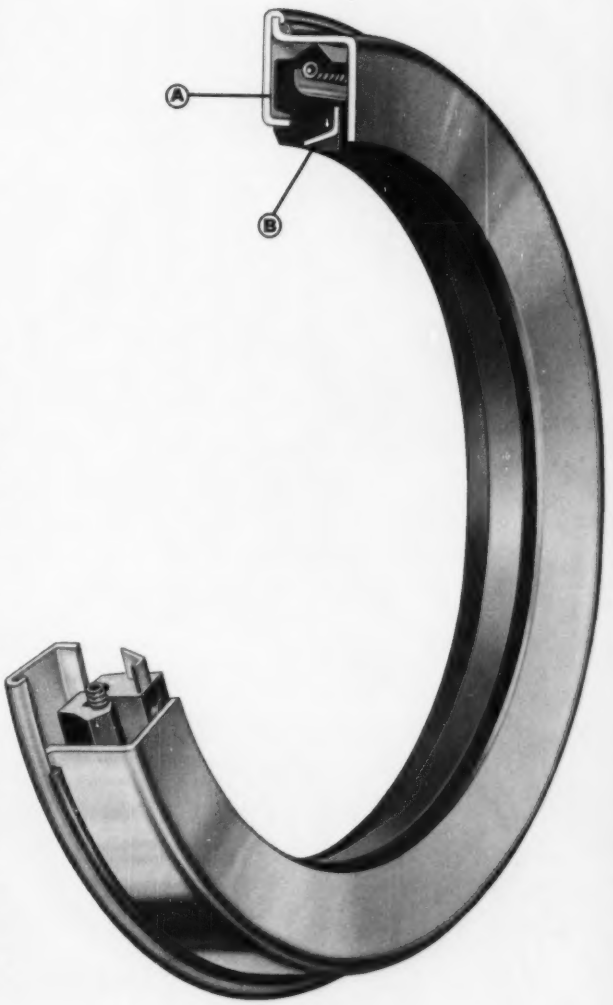
UNIQUE DESIGN The C/R SCOTSEAL is designed and constructed to seal within itself. In effect it is a self-contained oil sealing cartridge. This sealing cartridge consists of two parts which have relative motion to each other. In the illustration above, the outer Unit (A) is an encasing member. A portion of the inner surface of this shell serves as the surface against which the sealing member runs. The inner unit (B) is the metal reinforced, bonded synthetic rubber sealing member. In the external design, illustrated, the sealing member pushfits over the shaft and becomes a part of it—actually moving *with* it—and the metal case or shell pressfits into the housing bore. On internal designs, the sealing surface pushfits on the shaft and the sealing member is contained in the shell which pressfits in the bore.

PRE-LUBRICATED Since the sealing element is enclosed, prelubricant applied during fabrication stays in place and lubrication is supplied to the sealing lip through centrifugal action, giving extra protection particularly during starved conditions. Where the seal will be exposed to considerable dirt and water, a dirt lip is provided. Also, drain holes can be provided in the shell adjacent to the dirt lip. Centrifugal force will then sling dirt and water out . . . keeping the C/R SCOTSEAL as free as possible from abrasive elements.

ECONOMICAL Significant savings or cost reductions can be realized with the C/R SCOTSEAL. Where normal lip-type seals ideally require a shaft surface finish of 5 to 15 microinches and minimum hardness of Rockwell C30, no special finish or hardness is required for the SCOTSEAL. Shafts need not be specially hardened, ground and polished over the area where the seal contacts the shaft. Nor are wear sleeves shrink-fitted on the shaft required. All of these operations are eliminated when the C/R SCOTSEAL is used. The savings in machining costs alone will more than offset the slightly higher first cost of the seal. And there is no possibility of lip damage in installation. Additional dependability and quality will accrue to your assembly in the minds of the end-user. There will be no scored shafts to remove and refinish. Replacement of the SCOTSEAL, if necessary, is a quick, simple procedure. Thus, equipment downtime and maintenance costs will be reduced.

APPLICATION The C/R SCOTSEAL is currently providing increased sealing efficiency and extended service life on truck, bus and trailer axles. Its advantages indicate application wherever a high production run is involved; where oil retention is difficult; and where equipment downtime and replacement costs are critical. In broad terms, the SCOTSEAL may be used wherever an oil-tight press is possible.

(SEE ILLUSTRATIONS ON OTHER SIDE)

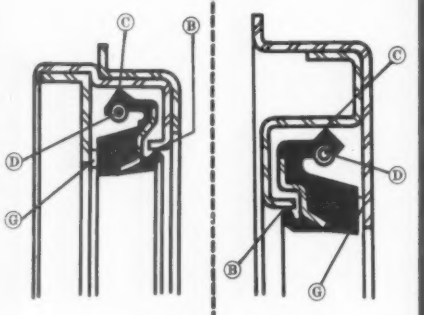


* Self Contained Omnipurpose Type SEAL. Trade Mark

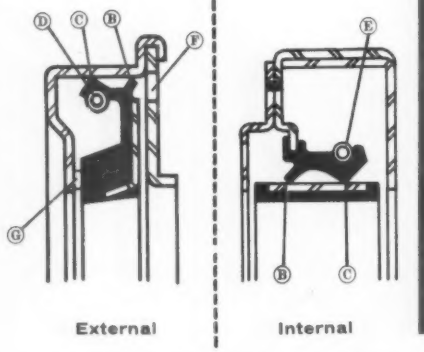
Shaft Type Scotseals...

The versatility of the basic C/R SCOTSEAL concept is illustrated below. Note the many different configurations, as well as material combinations, that can be developed, all embodying the self-contained principle, but fitting ideally the requirements of various applications.

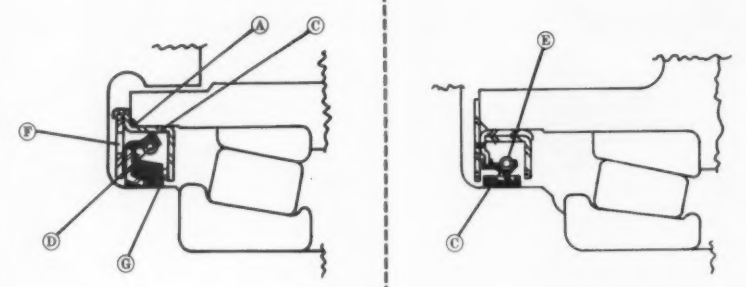
TYPICAL INSTALLATIONS...SEALING BEARINGS

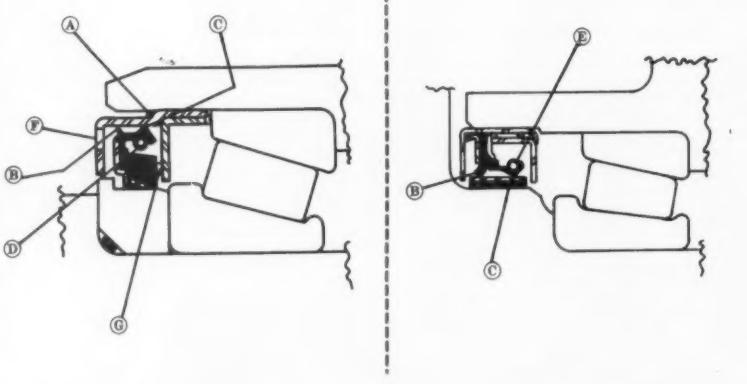


External Type SCOTSEALS



External Internal





LEGEND: **(a)** Sirvene Gasket **(b)** Dirt Lip **(c)** Sealing Lip **(d)** Expanding Spring **(e)** Contracting Spring **(f)** Drain Hole **(g)** Chaplets—keep sealing element spaced axially within its shell to insure proper installation.

Investigate this seal further. It will reduce costs for you and the ultimate user of your equipment where large production quantities are involved, and leakage, downtime and replacement are critical factors. C/R Oil Seal engineers will gladly recommend the correct C/R SCOTSEAL design for your application. Get in touch today.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1301 Elston Avenue, Chicago 22, Illinois

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Bradford, Ontario
Export: Geon International Corp., Great Neck, New York

DTR 4/60 Copyright 1960 by Chicago Rawhide Mfg. Co. Printed in U.S.A.

To OEM's who want to reduce the size of their control panels

The small size of General Electric panel components offers OEM's the opportunity to reduce the size of their panels up to 40%. Consider these two examples:

Example 1: Suppose you lay out a panel—including several size 1 or 2 starters or contactors—and the devices you choose fill up 900 square inches of space. To meet JIC standards, you must then enlarge your panel to 1170 square inches (adding 30% of clear panel mounting space). Because General Electric starters and contactors in these sizes are from 10 to 50% smaller than those of major control suppliers, you can avoid enlarging your panel beyond 900 square inches by using G-E devices. And you can still meet the standards and save on the sheet metal and labor required for a larger panel.

Example 2: If you build motor control centers in 7-, 9¼-, and 14-inch modules, you can stack General Electric size 2 starters eight compartments high. (This compares to five for most leading control manufacturers.) Thus you can save in steel work and up to 40% in the user's floor space.

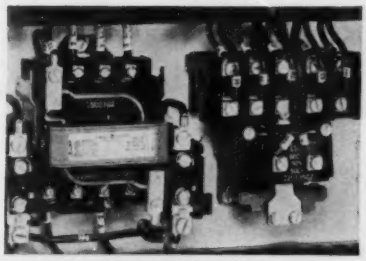
Similar advantages of small size, minimum wiring time, mounting convenience, and fast delivery are available with not only starters and contactors but also with General Electric relays, pneumatic timers, and push buttons. You can get *some* of these advantages from other manufacturers of panel components, but General Electric offers *all* these measurable advantages — and the greatest over-all savings to you.

For more information, contact your General Electric Apparatus Sales Office or request bulletins GEA-7020 (magnetic starters), GEA-7021 (relays), and GEA-5779 (oil-tight push buttons) from General Electric Company, Section 811-09, Schenectady 5, N. Y.

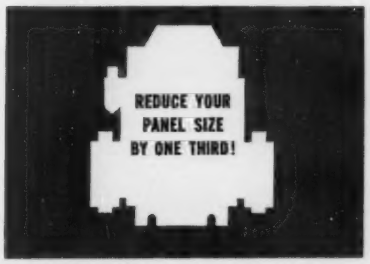
You get **MEASURABLE ADVANTAGES WITH GENERAL ELECTRIC CONTROL**

Progress Is Our Most Important Product

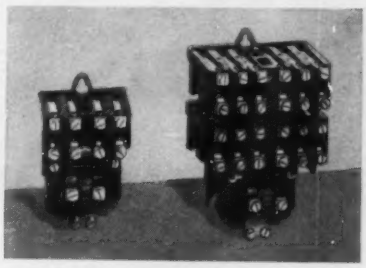
GENERAL ELECTRIC



SIZES 0 AND 1 STARTERS are 42% smaller than previous forms and about the same height as G-E 4- and 6-pole machine tool relays. Straight-through wiring means no looping of wiring around sides; only ½-inch side spacing required between starters.



SIZE 2 STARTERS are 34% smaller than previous forms; can reduce your panel space by 1/3. Wiring, coil, contacts, and overload relays are all accessible and removable from the front, eliminating need for extra space around the device.



COMPACT RELAYS save space, simplify installation and inspection. Less wiring room is needed because all terminals are in front. Machine tool relays are available in 2- through 12-pole forms.

2-IN-1 ILLUMINATED PUSH BUTTON replaces standard oil-tight button and light. This means a saving in money and a measurable 50% saving in space.

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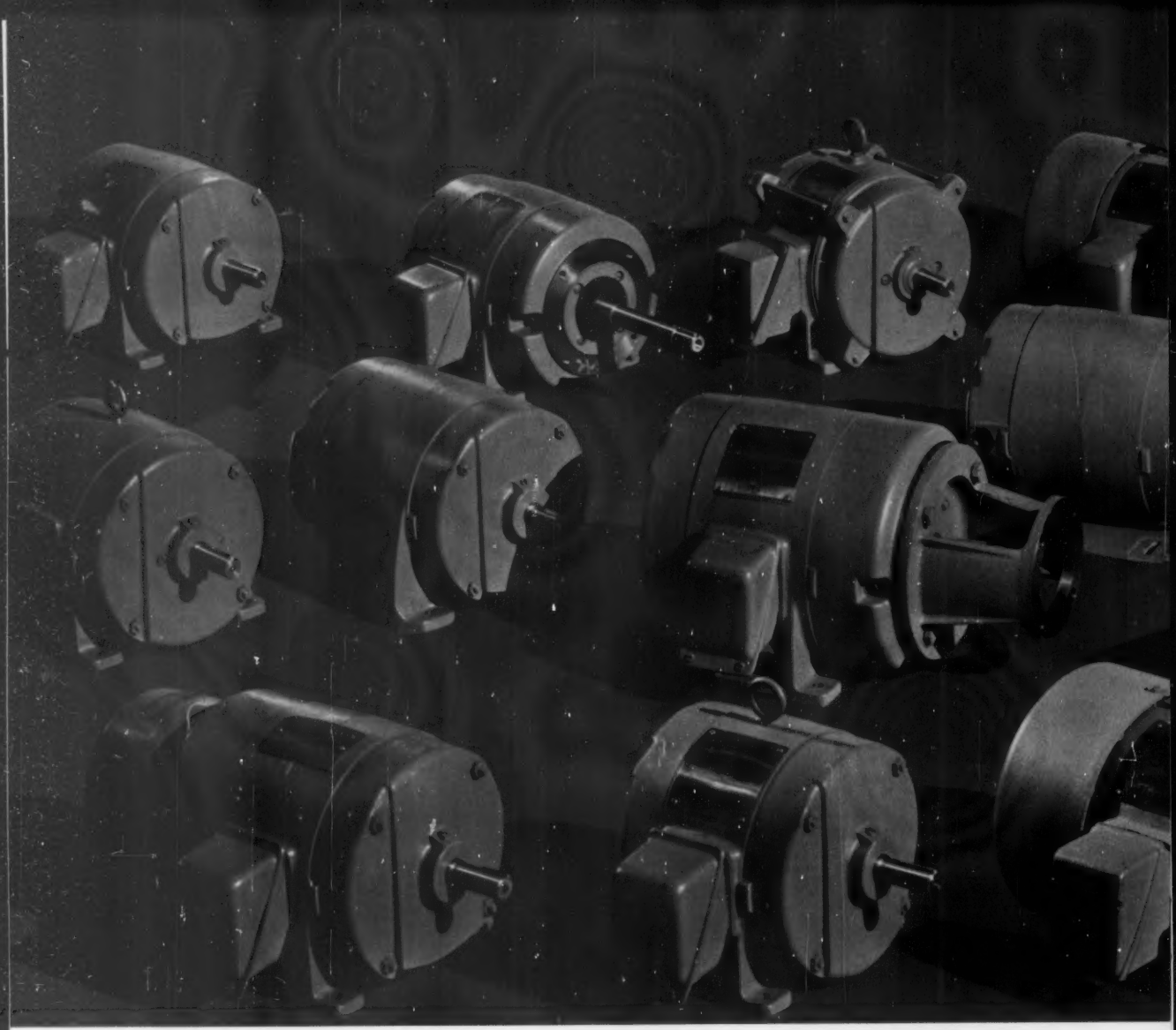
Circle 443 on Page 19→



How General Electric's TRI 55 CLAD motor gives you MORE THAN A MOTOR...

IT'S 10 TO 1 THE MOTOR YOU NEED IS IN THIS PICTURE

Good odds, aren't they?

And true. The Tri/Clad '55' motor constructions shown above will meet an estimated 91 percent of all applications for small integral-hp motors. Add to this literally thousands of electrical variations possible and you can see: ***There's an exact Tri/Clad '55' motor for your application.***

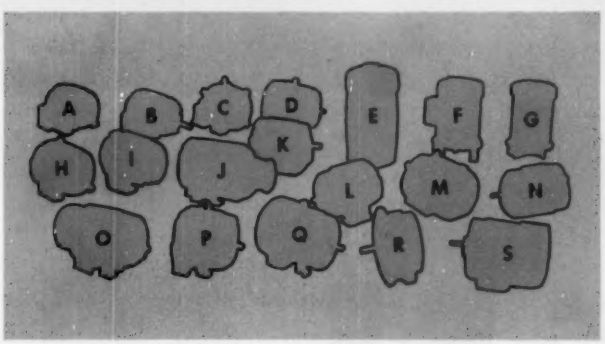
You may choose the rugged, versatile Tri/Clad '55' standard motor. Or, if yours is a special application, there's a complete line of industry-specified motors to choose from. Also, G-E engineers will help you tailor a Tri/Clad '55' motor to meet unusual requirements.

Why not investigate the full line of General Electric Tri/Clad '55' motors today? You'll find Tri/Clad '55' motors give you *more* than a motor . . . in outstanding performance characteristics and many unpaid-for "extras." Contact your nearby G-E Apparatus Sales Office or write Section 840–29, General Electric Co., Schenectady 5, N. Y.

Other "More Than A Motor" Benefits of G-E Tri/Clad '55' Motors: On-time Delivery • Expert Application Aid • Fast, Local Backup Service • Constant Design Innovation • Durable, Long-life Performance.

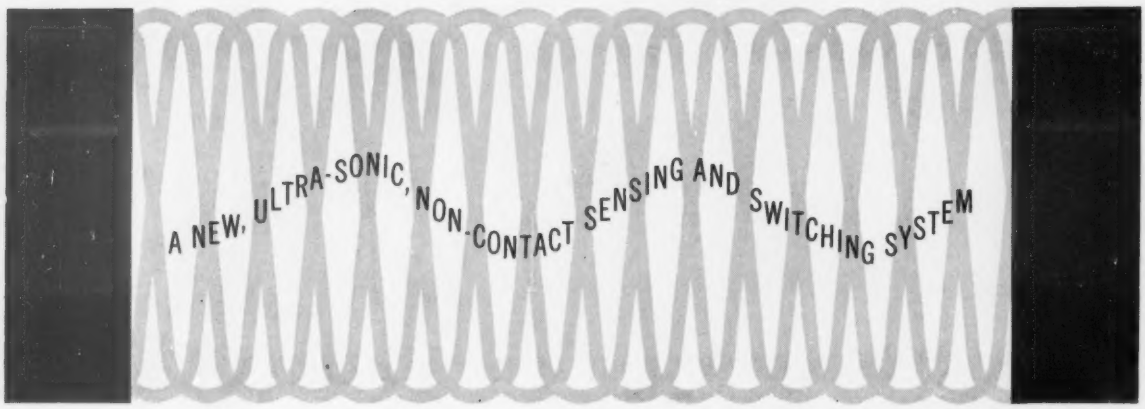
GENERAL ELECTRIC

A FULL LINE of General Electric Tri/Clad '55' motors means you can get the right motor for every application.



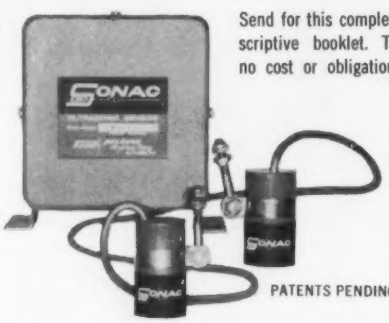
FULL LINE of Tri/Clad motors includes: (A) Footed dripproof, polyphase (B) C-face, close-coupled pump (C) Explosion-proof, non-vent (D) TEFC (E) Vertical, hollow-shaft (F) Vertical, solid-shaft, P-base, single-phase (G) Vertical, solid shaft, P-base, polyphase (H) Enclosed, air-over (I) Single-phase, general-purpose (J) Hydraulic pump (K) Dripproof, resilient base (L) Single-phase, farm motor (M) Explosion-proof, fan-cooled (N) C-face, round-frame (O) Brake motor (P) Enclosed nonventilated, polyphase (Q) TEFC, severe-duty (R) Thinline, enclosed (S) Fan-cooled, single-phase. All give Tri/Clad '55' motor quality.

A GENERAL ELECTRIC APPLICATION ENGINEER, working with your engineers, can provide valuable assistance in helping you solve unusual motor application problems. He can bring years of integral-horsepower motor experience and knowledge into action for you.



SONAC

Here truly is a new dimension in automated controls! Delavan's new SONAC uses ultrasonic energy for its "beam". This new concept offers many advantages over available sensing devices. SONAC has no lamps to burn out . . . nothing to replace . . . eliminates down time. SONAC is unaffected by vibration, dust, industrial contamination or ambient light. SONAC will sense ferrous and non-ferrous metals, liquids or solids, transparent or opaque materials, yet requires less power than an ordinary flashlight. These are a few of SONAC's advantages.



Send for this complete descriptive booklet. There's no cost or obligation.

PATENTS PENDING

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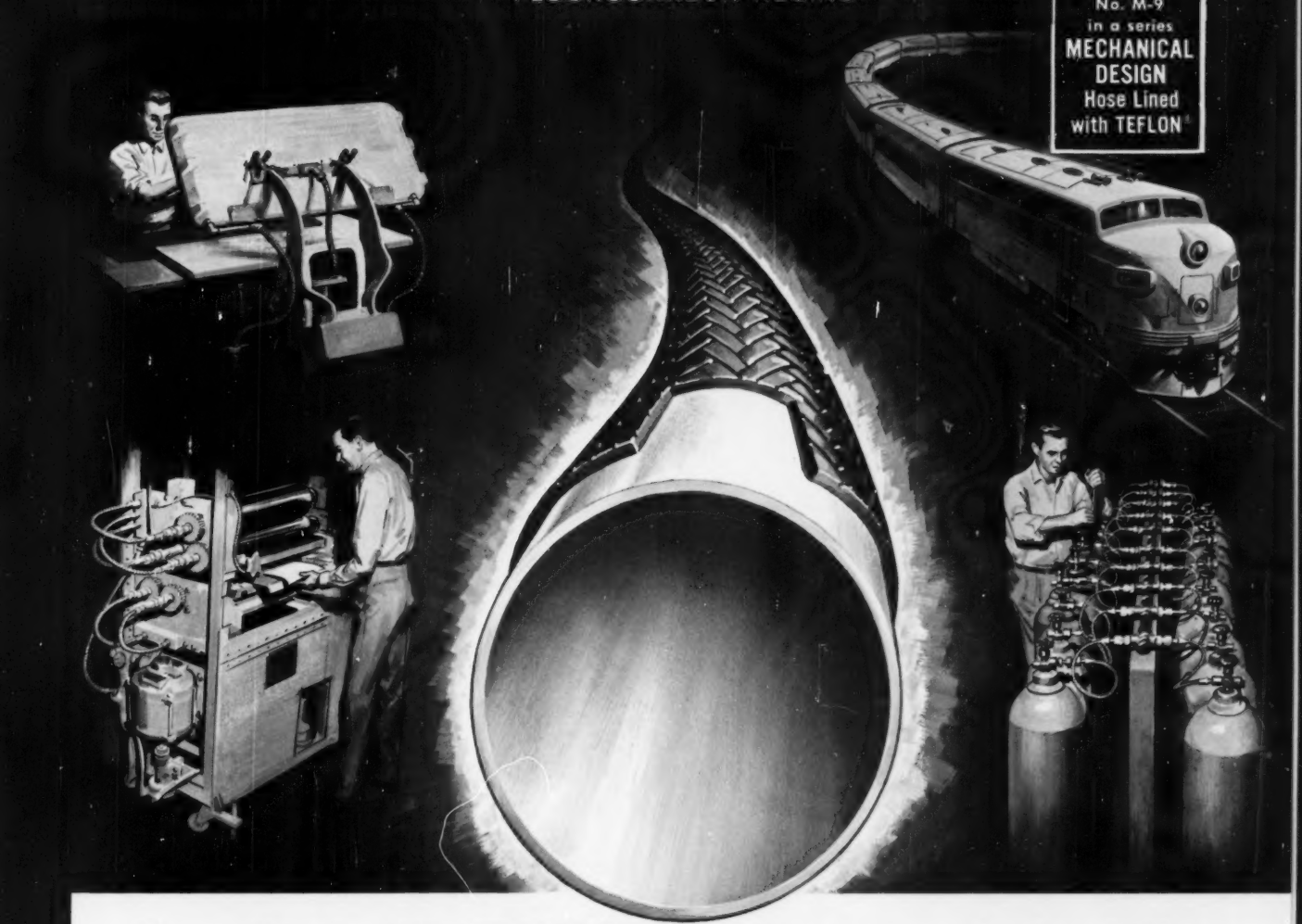
DU PONT

ENGINEERING FACTS ABOUT

TEFLON®

FLUOROCARBON RESINS

No. M-9
in a series
MECHANICAL
DESIGN
Hose Lined
with TEFLON®



Hose lined with TEFLON® provides economical solution to the most difficult fluid-handling problems

In any fluid-handling service involving such problems as temperature extremes . . . threat of corrosion . . . continuous flexing, torque or vibration . . . high pressures . . . adhesion of sticky substances, the use of hose lined with TEFLON TFE fluorocarbon resins provides a uniquely effective solution. Such hose can give longer life and better performance, cut replacement and maintenance expenses, prevent costly downtime, and in fact do jobs for which conventional hose could not have been considered.

TEFLON resins are inert to virtually every chemical and solvent. The TFE resins are rated for continuous use up to 500° F.

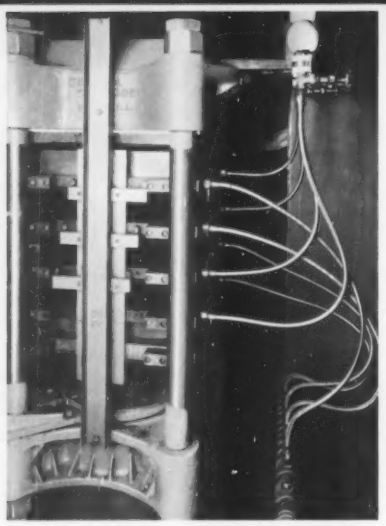
Hose lined with TEFLON also offers long flex life, easy cleanability and unique anti-stick properties. With reinforcing, service pressures up to 6,000 psi are being achieved.

A wide selection of industrial hose constructions with liners of TEFLON TFE resins is now available to meet your needs. In addition to the wire braided reinforcement and a variety of industrial couplings, there are elastomer coverings, fiber braids and convoluted liners of TEFLON for extra flexibility.

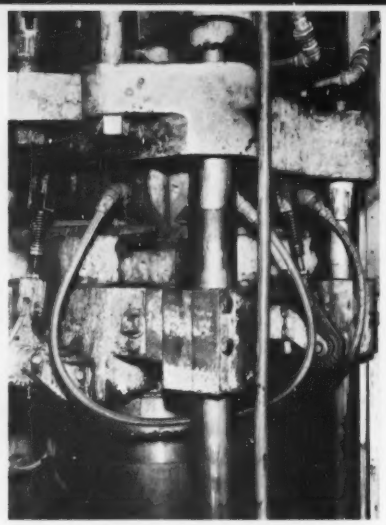
On the following page you will find some examples of the cost-cutting advantages made possible by hose lined with TEFLON TFE fluorocarbon resins.

OVER

Hose lined with TEFLON® offers high heat resistance . . . long flex life . . . unsurpassed durability

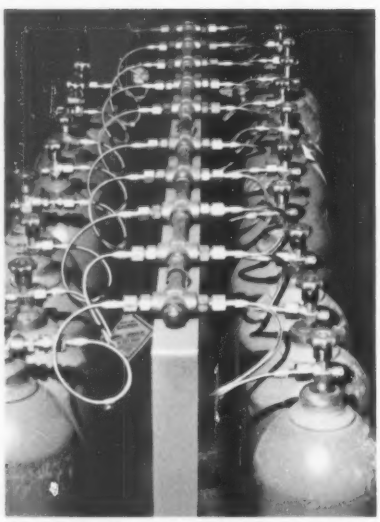


HEAT RESISTANCE: Hose is in alternate 350°F. steam and cold water service on this plastics platen press. Prior to the use of hose lined with TEFLON, scale formation plugged the hose in a matter of months. After 5 years, seven hoses lined with a TEFLON TFE resin were still unharmed and unplugged.

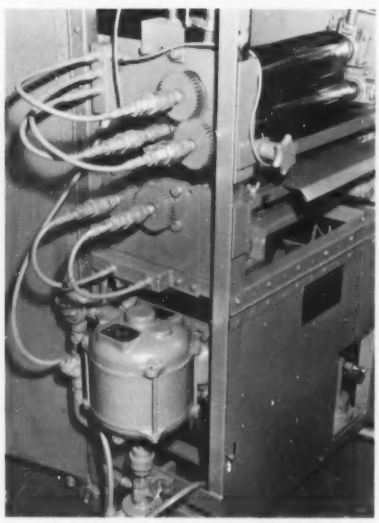


HEAT RESISTANCE: Steam press used in the manufacture of battery casings relies on hose lined with TEFLON to withstand tough operating conditions. Eight hoses are used in each of the steam presses, which have operated more than three years without a hose failure. Hoses formerly used were replaced every few months.

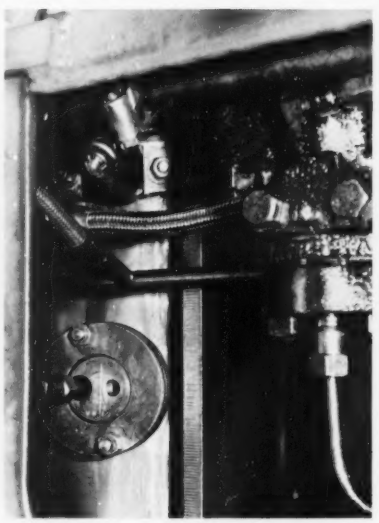
LONG FLEX LIFE: Cleaners and garment manufacturers are now using hose lined with TEFLON fluorocarbon resins carrying steam to their presses. Above is one of 100 units at a location so equipped 16 months ago, and there have been no failures. Previously, hose life on some units was as low as two weeks.



LONG FLEX LIFE: At this plant, rubber hoses or metal pigtails lasted 3 months at best, loading helium, nitrous oxide, and carbon dioxide into cylinders. Hoses lined with TEFLON show no deterioration after 16 months. Reduced stiffening and frosting at the 0°F. loading temperature improved the weighing accuracy.



DURABILITY: Hose lined with TEFLON TFE resin helped adapt this standard roller coater machine to corrosive high-temperature service. To suit customers' needs, the hose had to handle heat transfer oil at up to 400°F. Hose lined with a TEFLON TFE resin provided the necessary resistance to heat and solvents.



DURABILITY: Fuel header of a locomotive uses 12 feet of hose lined with TEFLON to carry fuel to the injector pumps. These fuel lines have demonstrated exceptional durability in service. They have been installed on 5 locomotives, and will be put on all locomotives as they come in to be overhauled.

FOR MORE INFORMATION about reliable hose installations, and the design properties of Du Pont TEFLON resins that make possible this superior hose performance, consult your hose supplier or write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department T-2569, Room 2526, Nemours Building, Wilmington 98, Delaware.
In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

TEFLON®

FLUOROCARBON RESINS

TEFLON *is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resin.*

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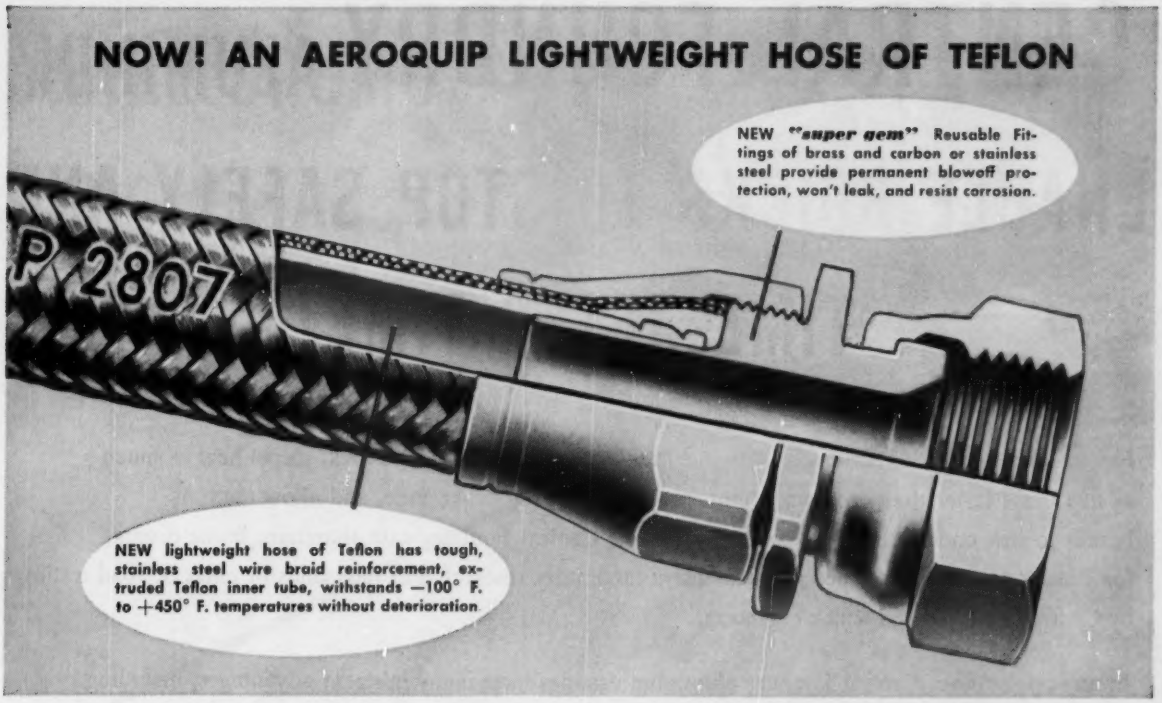
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

NOW! AN AEROQUIP LIGHTWEIGHT HOSE OF TEFLON


NEW "super gem" Reusable Fittings of brass and carbon or stainless steel provide permanent blowoff protection, won't leak, and resist corrosion.
P 2807
NEW lightweight hose of Teflon has tough, stainless steel wire braid reinforcement, extruded Teflon inner tube, withstands —100° F. to +450° F. temperatures without deterioration.

New Design Reduces Cost of Hose of Teflon

LOWER COST OF NEW AEROQUIP 2807 & 2808 HOSE OF TEFLON PERMITS WIDE USE IN STEAM AND CHEMICAL APPLICATIONS

Development of Aeroquip 2807 and 2808 Hose of Teflon extends the practical use of this high temperature, chemically inert hose type to many new applications. The new lightweight design of both Hose of Teflon and its patented* "*super gem*" Reusable Fitting achieves a manufacturing savings compared to other Teflon hose, without sacrifice in quality. This savings is passed on to you.

Exceptionally long service life is possible in steam and chemical use, even where flexing and vibration are constant problems. Operating temperature limits are —100° F. to +450° F.† The unique "*super gem*" Fittings are leakproof and blowoff proof, yet can be detached and reused again and again. Fitting styles available include male pipe, J. I. C. swivel and 2-bolt swivel flange ends.

For complete engineering data on Aeroquip 2807 and 2808 Hose of Teflon, fill in and mail the coupon below.

†For applications requiring higher temperatures, please contact Aeroquip's engineering department.

Hose No.	O.D. Tube Size	Working Pres., psi. Steam*	Working Pres., psi. Chemical	Min. Burst psi.	Min. Bend Rad., Ins.
2807-4	¼	200	1500	10000	2
2807-5	5/16	200	1500	9000	3
2807-6	⅜	200	1500	8000	4
2807-8	½	200	1000	6000	5¼
2807-10	⅝	200	800	6000	6½
2807-12	¾	200	800	5000	7¾
2807-16	1	200	800	3500	9
2807-20	1¼	200	600	2800	16
2808-8	½	200	1500	8000	4⅜
2808-10	⅝	200	1500	8000	5½
2808-12	¾	200	1000	8000	6½
2808-16	1	200	1000	5000	7⅜
2808-20	1¼	200	800	4000	11

*388° F. maximum recommended steam temperature

Aeroquip offers a complete Fluid Piping Service to equipment manufacturers, with assistance in any phase of manufacture.

- DESIGN
- PROTOTYPE
- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

"*super gem*" is an Aeroquip trademark. *U.S. Patent Nos. 2,833,567 and 2,731,279. Teflon is DuPont's tradename for its tetrafluoroethylene resin

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Aeroquip Corporation, Jackson, Michigan

Please send me a copy of Bulletin IEB-50 covering 2807 and 2808 Hose for steam and chemical applications.

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Title_____

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←Circle 445 on Page 19

Circle 446 on Page 19

CENTRAL FOUNDRY ALUMINUM

ENABLE BUICKS TO STOP SAFELY AND TIME AFTER TIME!

Finned aluminum brake drums, cast by Central Foundry and used by Buick, dispel heat as much as five times faster than ordinary drums, practically banish brake fade, and allow the brakes to stay cooler, stop better and last longer. Central Foundry cast aluminum brake drums for Buick cars were developed after extensive laboratory research and thousands of miles of road testing by Central Foundry and Buick engineers.

In any application, Central Foundry aluminum castings have many inherent advantages, including light weight, machinability, corrosion resistance and excellent heat and electrical conductivity.

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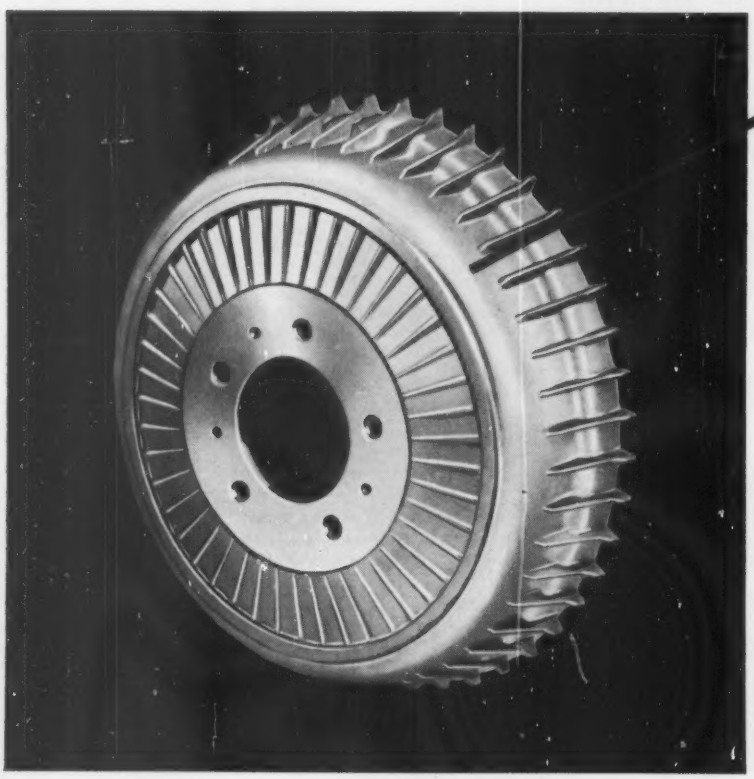

For assistance in the design, alloy specification and in the choice of the casting method best suited to the production of your part—write today for the new 24-page book on Aluminum Castings or ask for a Central Foundry sales engineer to call.

BRAKE DRUMS SURELY...

1960 TURBINE DRIVE BUICK LE SABRE

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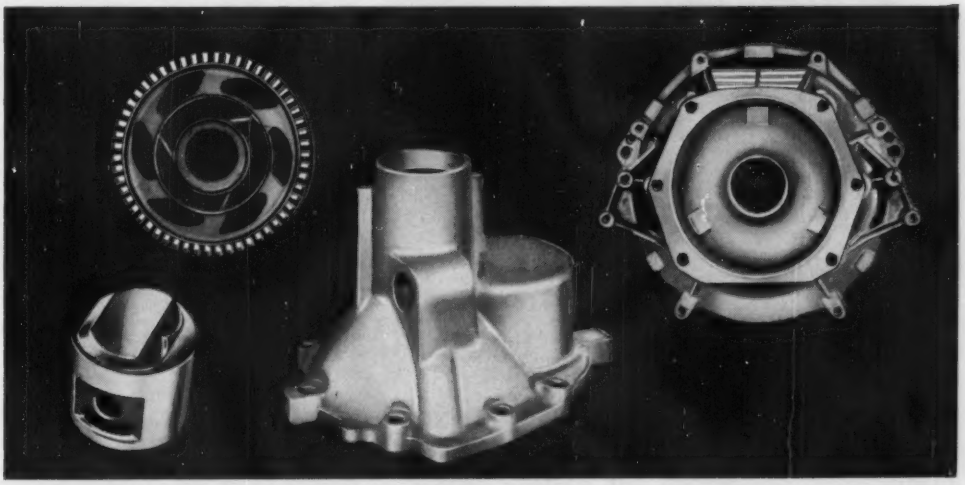

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ALUMINUM CASTINGS FOR AMERICA'S NEW CARS

Dozens of automobile components are being developed, tested and produced in aluminum which are greatly aiding car manufacturers in their efforts to lower weight, reduce costs and, at the same time, increase the economy and performance of their cars.

A FEW OF THE HUNDREDS OF ALUMINUM CASTING APPLICATIONS INCLUDE:

Intake Manifold	Oil Pan
Water Pump Body	Oil Pump Body
Timing Chain Cover	Transmission Case
Water Outlet	Steering Gear Housing
Brake Master Cylinder	Differential Carrier

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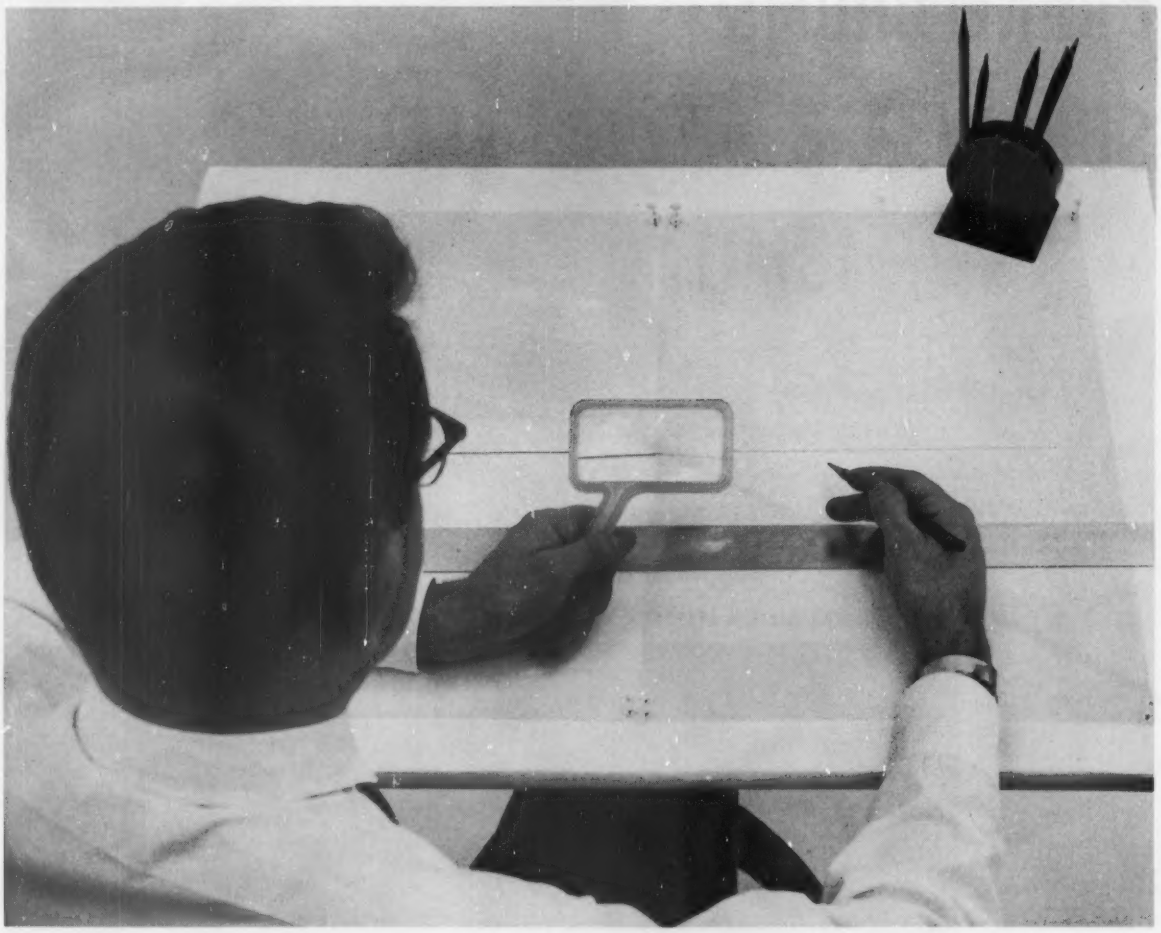
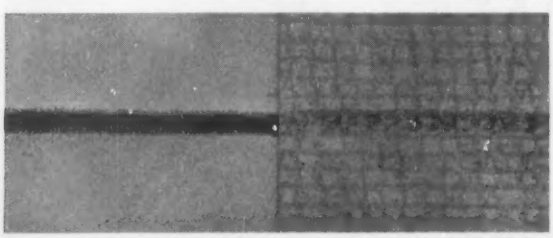
Simple Pencil Test Affords Dramatic Proof:



CRONAFLEX® HAS THE BEST DRAFTING SURFACE YOU CAN USE!

Here's an easy way to prove to yourself the superior draftability of CRONAFLEX: place a sheet of it on your drawing board, side by side with whatever drafting material you've been using. Now draft several lines on each. Erase and re-draft. Use your own tools, your own techniques.

Examine the lines you've drawn with a magnifying glass. Notice the difference in covering power, cleanness of erasures and line density—especially where lines have been re-drawn. You've just demonstrated three important reasons why CRONAFLEX is the best drafting film available: excellent *pencil acceptance*, outstanding *erasability* and good *re-drafting characteristics*.



Compare pencil acceptance of CRONAFLEX (left) with that of ordinary drafting material. Same pencil made both impressions! CRONAFLEX gives a faster, cleaner, lighter touch, too, because you don't have to bear down as you must with cloth.

CRONAFLEX has other advantages, as well. Its rugged "Cronar"* polyester base holds its size and resists kinking. It's .004" thick for easier, more efficient handling. Because CRONAFLEX is manufactured from start to finish by Du Pont, you're assured of consistent performance found in no other drafting film. To learn more, write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware.

*Du Pont's trademark for its polyester photographic film base.

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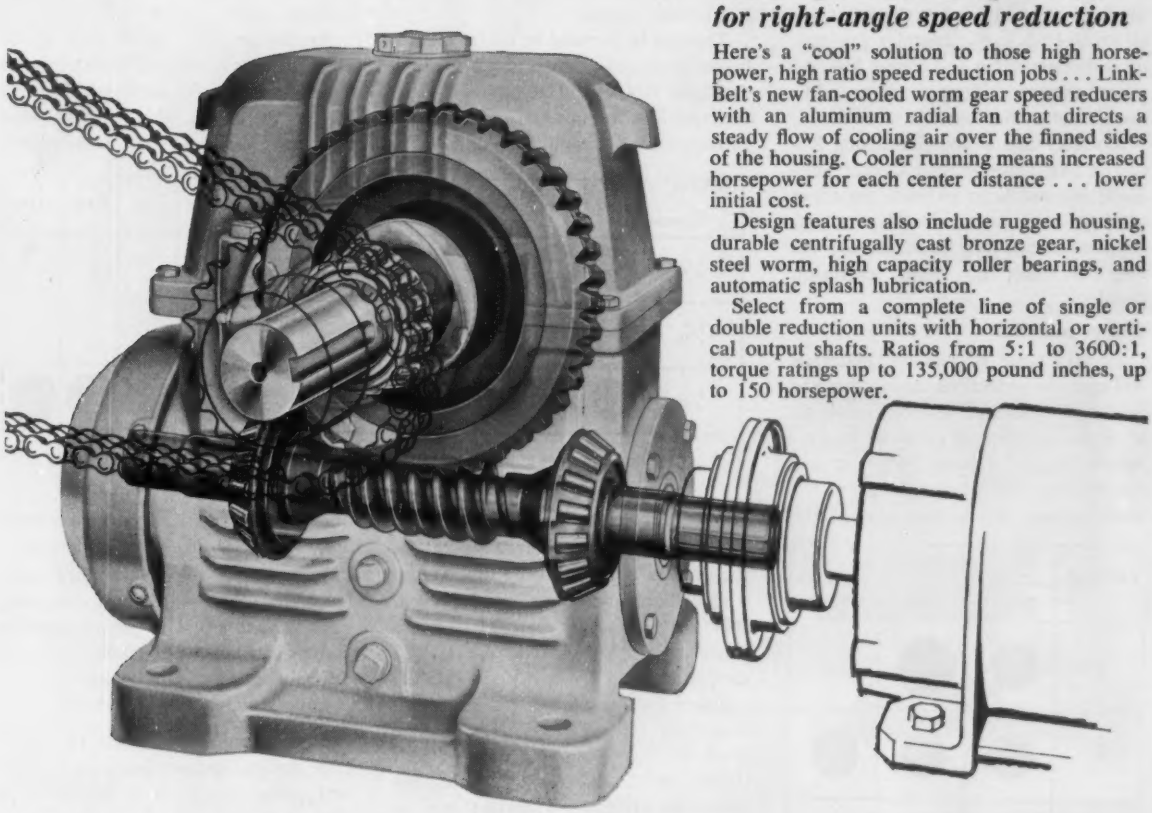
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

NEW LINK-BELT WORM GEAR SPEED REDUCERS

fan-cooled high capacity compact



Industry's most complete line for right-angle speed reduction

Here's a "cool" solution to those high horsepower, high ratio speed reduction jobs . . . Link-Belt's new fan-cooled worm gear speed reducers with an aluminum radial fan that directs a steady flow of cooling air over the finned sides of the housing. Cooler running means increased horsepower for each center distance . . . lower initial cost.

Design features also include rugged housing, durable centrifugally cast bronze gear, nickel steel worm, high capacity roller bearings, and automatic splash lubrication.

Select from a complete line of single or double reduction units with horizontal or vertical output shafts. Ratios from 5:1 to 3600:1, torque ratings up to 135,000 pound inches, up to 150 horsepower.

FOR FULL-LINE FACTS

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- ☐ motogears—Catalog 2747
- ☐ in-line helical gear speed reducers—Catalog 2751
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Circle 449 on Page 19

GASKET EXTRUSION

When gaskets extrude, serious loss of bolt torque often follows. Research indicates that several factors are involved . . . and shows how many extrusion problems can be avoided.

E. M. SMOLEY
Research Physicist
Armstrong Research and Development Center

Flange pressure . . . temperature . . . the kind of gasket and its thickness . . . all are factors in the complex problem of gasket extrusion and torque loss. At times, aluminum flanges are an additional factor that must be considered.

Studies made at the Armstrong Research and Development Center have made it possible to estimate the effect of these various factors. As a result, suggestions can now be made that will help to clear up many extrusion problems.

Gasket material

Certain types of resilient materials will extrude more than others. Straight rubber, for example, is incompressible. If it is deflected beyond its recommended range (about 20%) it will simply flow out of the flange. To a lesser extent, this is true also of the less "corky" cork and rubber gaskets.

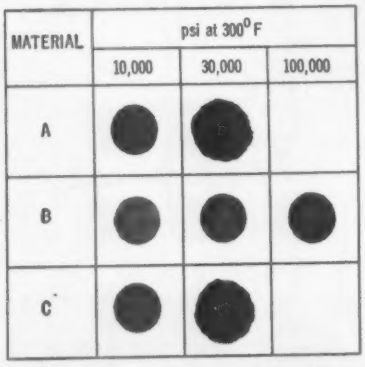

Figure 1. Test samples of conventional fiber materials (A and C) show extensive crushing at 30,000 psi. Accopac AN-890 (B) is not affected at 100,000 psi.

Fiber materials have the least tendency to extrude, but they will often give difficulty where heat and high flange pressure are encountered. The reason is that high temperatures tend to soften conventional fiber materials, allowing the gasket to flow and causing loss of bolt torque.

This can be avoided by using a dense beater-saturated asbestos stock such as Accopac AN-890. The photo at left demonstrates the unusual resistance to extrusion and crushing of AN-890.

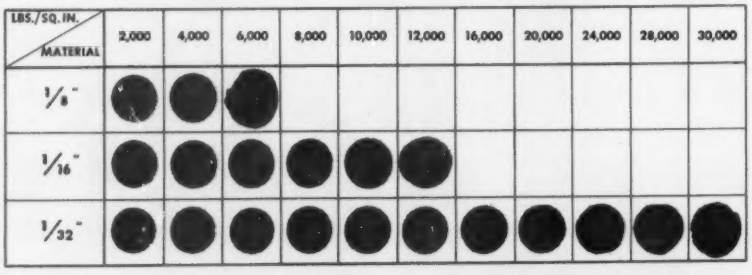

Figure 2. Results of hot extrusion test on cork-and-rubber gasket material. Tests were conducted at 200° F., with thickness the only difference between samples.

Gasket thickness

Generally, the thicker a gasket is, the greater is its tendency to extrude. This is shown in the above photo. Note that a 1/32″ thick material has five times the crush resistance of the 1/8″ sample.

Fiber gaskets exhibit this same tendency to extrude at thicker gauges. In a test involving gauges of .015″, .030″, .065″, and .100″, the thinnest materials exhibited a torque loss of only .5% as against a loss of 76.5% for the thickest sample.

Aluminum flanges

The wide use of aluminum has increased problems of gasket extrusion. This is partly because high temperatures and high flange pressures are usually involved. But aluminum's coefficient of expansion — roughly twice that of cast iron or steel — adds another factor.

As flanges heat up to 300° F. or higher, the expansion of the aluminum flange substantially increases the unit load on the gasket. This increased load can cause extrusion of conventional fiber materials that might give acceptable service with cast iron flanges.

Where aluminum flanges are used, Accopac AN-890 is the recommended gasket material. This dense asbestos composition is being used in many critical applications involving high temperatures and high flange loads.

Detailed information on the selection, design, and performance of resilient gasket materials is contained in the Armstrong Gasket Design Manual. Write for your copy of this 32-page book today. Address Armstrong Cork Company, Industrial Division, 7106 Dean Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS
1860–1960 Beginning our second century of progress

Please direct inquiries to advertiser, mentioning MACHINE DESIGN
Circle 450 on Page 19→

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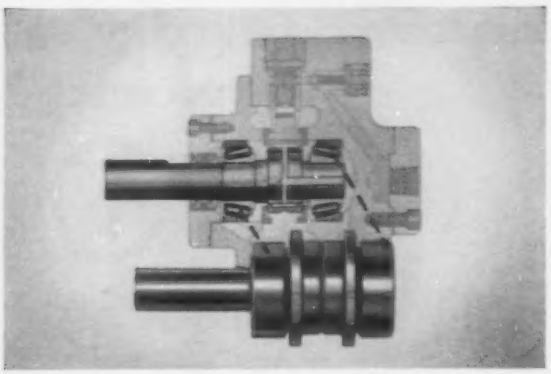
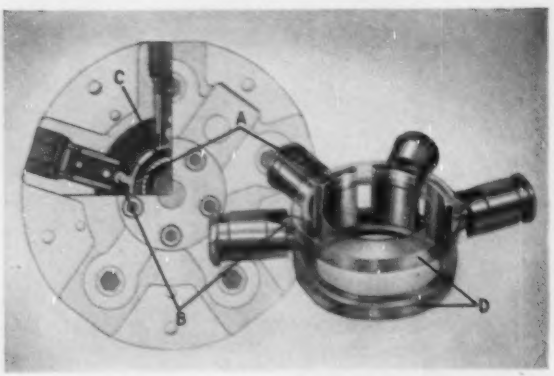
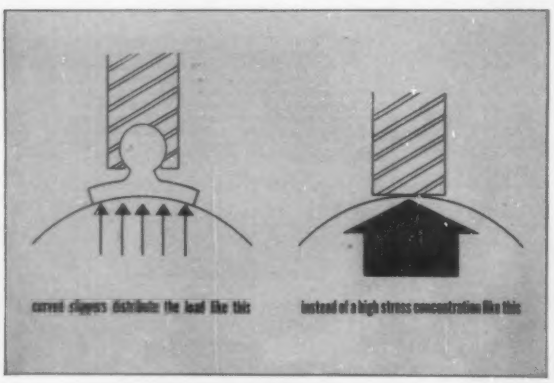
Only one hydraulic pump offers these 4 benefits... AE Hydramite®



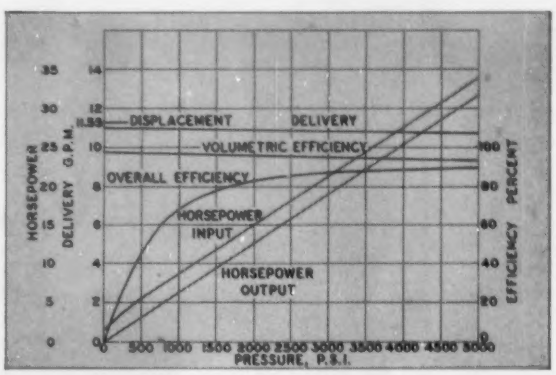
1. Tapered roller bearings. Two high-capacity, heavy-duty tapered roller bearings support the eccentric cam shaft. This means that a Hydramite can take more punishment... handle heavier unbalanced loads... and last longer. The pump casing is ported so that the pumping action of tapered bearings will provide better lubrication.



2. Positive pumping action. No cam follower springs to fail. Each plunger connects to a curved slipper (A) through a knuckle joint (B). In succession, plungers are pushed out by the cam shaft roller bearing (C) and pulled back by return rings (D) which hold each slipper snugly against outer race of the cam bearing.



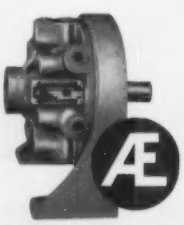
3. Curved Slipper distributes thrust load of its plunger and reduces unit stress to the point where maintenance is never required at what is a critical wear spot in most hydraulic pumps. Also, curved slippers riding on the outer race of the cam shaft roller bearing minimize scrubbing action between these parts.



4. High efficiency. With a Hydramite you get an overall efficiency of 85%. Shown above is typical 10 gpm pump curve. Its flat overall high efficiency has little variation between 1,500 and 5,000 psi. What's more, with a Hydramite you get positive suction. There is no need for supercharging equipment which reduces system efficiency.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 25 gpm at 5,000 psi and 60 to 100 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles.

Write or call American Engineering Company, Dept. P-147, Philadelphia 37, Pa. Phone: CUmberland 9-3800.



See our four-page catalog in Sweet's Product Design File, or write us for reprint (Catalog P-60).

AMERICAN ENGINEERING COMPANY

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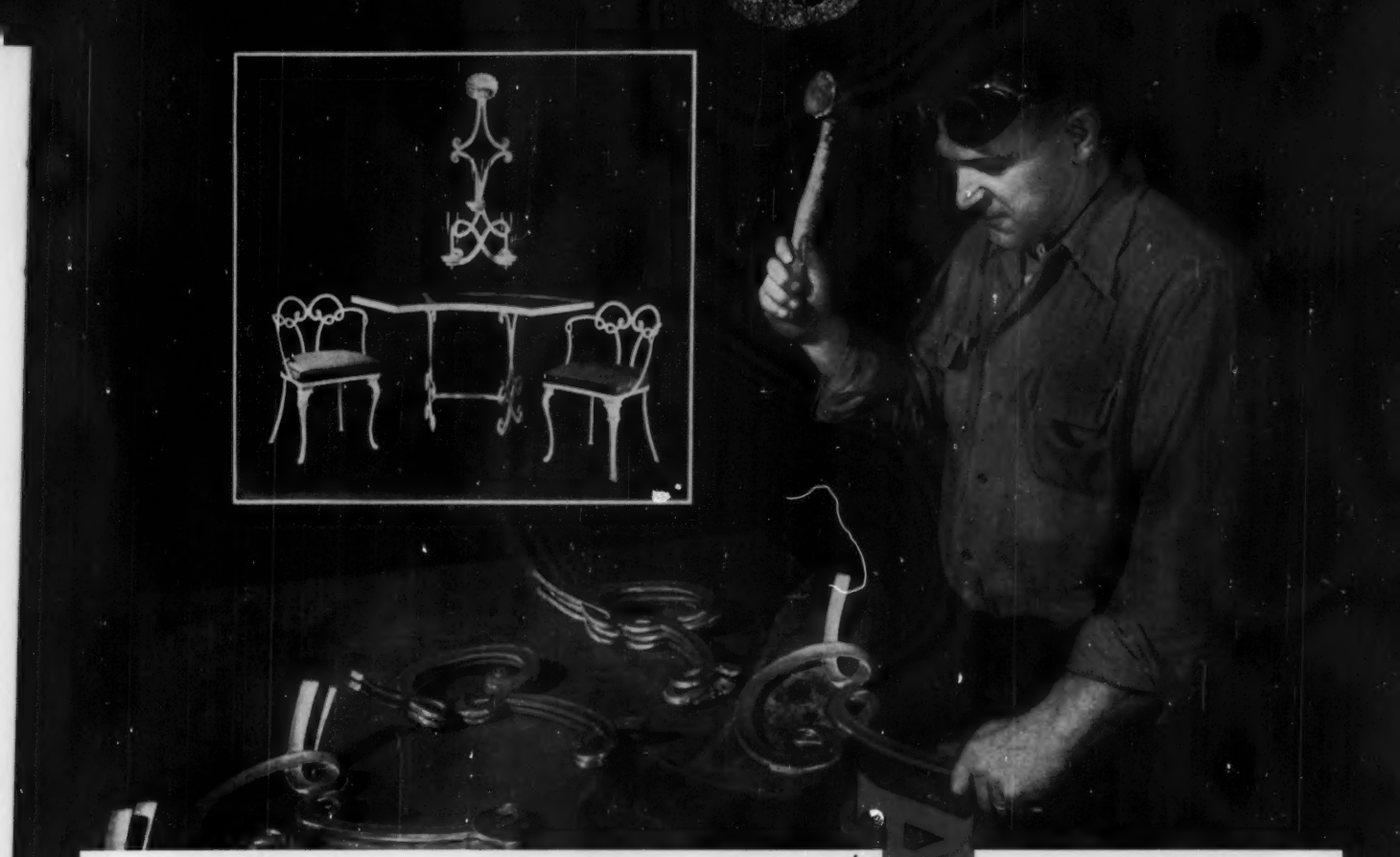
Hele-Shaw Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries, Vibra-Grate, Perfect Spread and Taylor Stokers.



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for complex cold forming

Adaptaloy, an exclusive Federated alloy, has the highest elongation and impact strength of any sand cast alloy not requiring special practices or heat treatment. It's an excellent lightweight material for moderate strength castings that must be cold formed or bent during processing or installation. Dimensionally stable, castable by conventional foundry methods, easily anodized and color dyed. Adaptaloy is being used successfully for ornamental grilles, ball joints, brackets, valve handles, furniture, clamps, machine parts. Write or call for descriptive booklet to Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N.Y. Telephone REctor 2-9500, or call your nearest Federated sales office.

Adaptaloy castings are easily cold formed and simplify assembly for the Sandfort Furniture Co., N. Y. Inset photo illustrates one of Sandfort's cast aluminum furniture settings—all are cast of Adaptaloy.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

FEDERATED METALS DIVISION

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Chicago: Essex 5-5000

IN CANADA: Federated Metals Canada, Ltd.
Toronto, Ont., 1110 Birchmount Rd., Scarborough, Phone: Plymouth 73246

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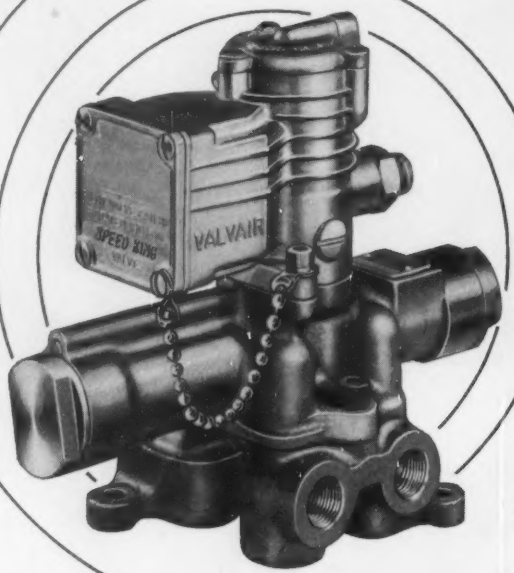
Circle 452 on Page 19

No coil burnout with SPEED KING®



...pilot operated control valves

• Built to JIC standards • interchangeable pilots • choice of mounting types, optional features • ac or dc, any voltage • ¼ to 1 in. NPT

SPEED KING solenoid pilot coils, potted in molded resin, are unconditionally guaranteed against coil burnout for the life of the valve! And, Speed King pilots are totally enclosed, and sealed against entrance of dirt or moisture . . . valves are fully air-operated for speed and dependability . . . feature a hard-chrome plated stainless steel plunger floating in O-rings, to eliminate wear-producing metal-to-metal contact.

For multi-million cycle dependability, specify Valvair® SPEED KING control valves.

8111-3

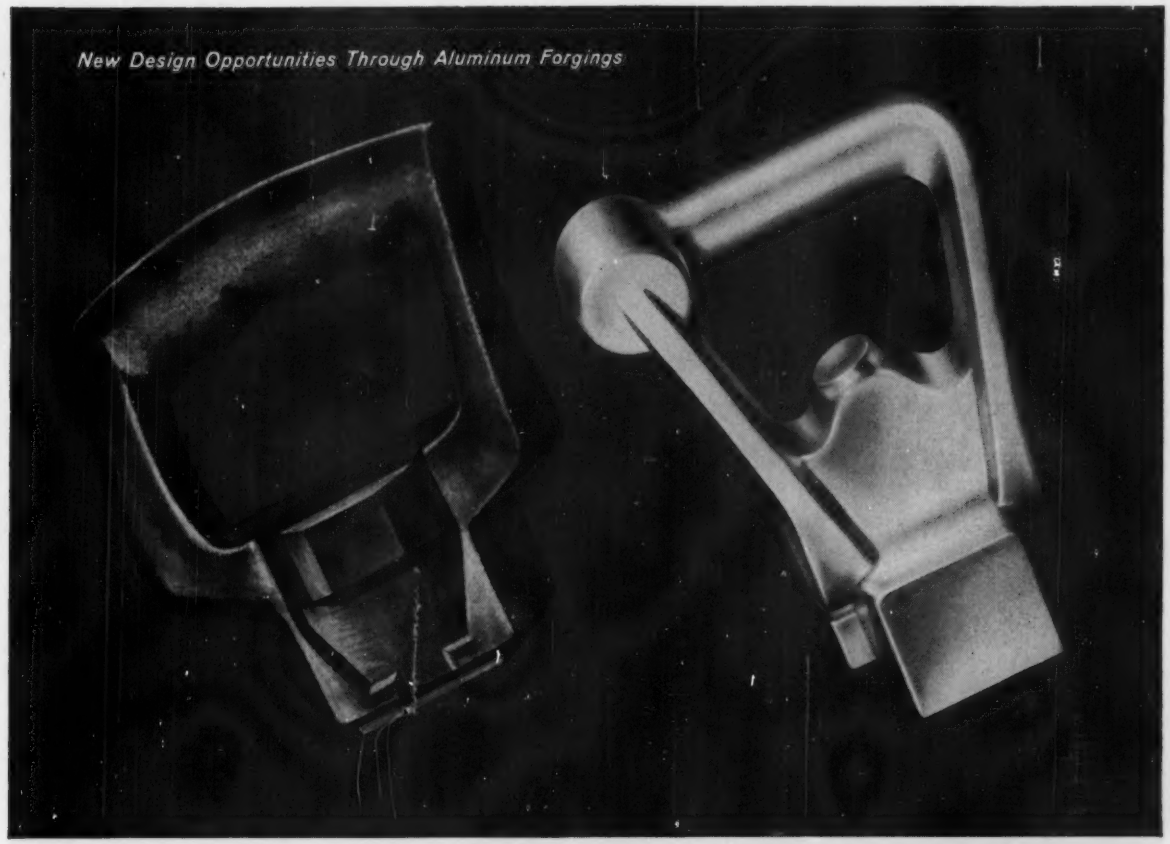
Write for free Bulletin SK-100. Address: Bellows-Valvair, Akron 9, Ohio, Dept. MD-660.

Bellows-Valvair

The Bellows Co. • Valvair Corp. Akron 9, Ohio

DIVISIONS OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

Circle 453 on Page 19



WHICH DRILL HANDLE HAS THE WEIGHT ADVANTAGE?

The handle on the right . . . because it's aluminum! This forged aluminum drill handle is a good example of how aluminum forgings are solving difficult design problems involving light, strong tool parts.

Previously, the handle was fabricated as an iron casting . . . and iron castings are *heavy,* as workmen using the drill soon found out. To lighten the worker's load, a search began for a new design that would reduce the weight of the handle, yet retain its strength.

Solution: the aluminum forging shown in the picture. It weighs only one-third as much as the old cast iron handle. Yet, due to the forging process, its strength is even greater. Grain flow lines of the metal follow the contour of the part, concentrate at points of greatest stress and shock to give the handle amazing strength.

This highly favorable strength-to-weight ratio is one reason why so many designers are turning to aluminum forgings for more and more commercial applications. Find out how aluminum forgings can best serve your requirements. We'll be glad to send you full details on aluminum forging availabilities, tolerances and hand forging designs—just mail the coupon!

KAISER ALUMINUM*

THE BRIGHT STAR OF METALS

*TRADEMARK KAISER ALUMINUM & CHEMICAL CORP.

Kaiser Aluminum & Chemical Sales, Inc.
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300 Lakeside Drive, Oakland 12, Calif.

Please send me the latest information on commercial aluminum forging availabilities, tolerances and hand forging designs.

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COMPANY _____

ADDRESS _____

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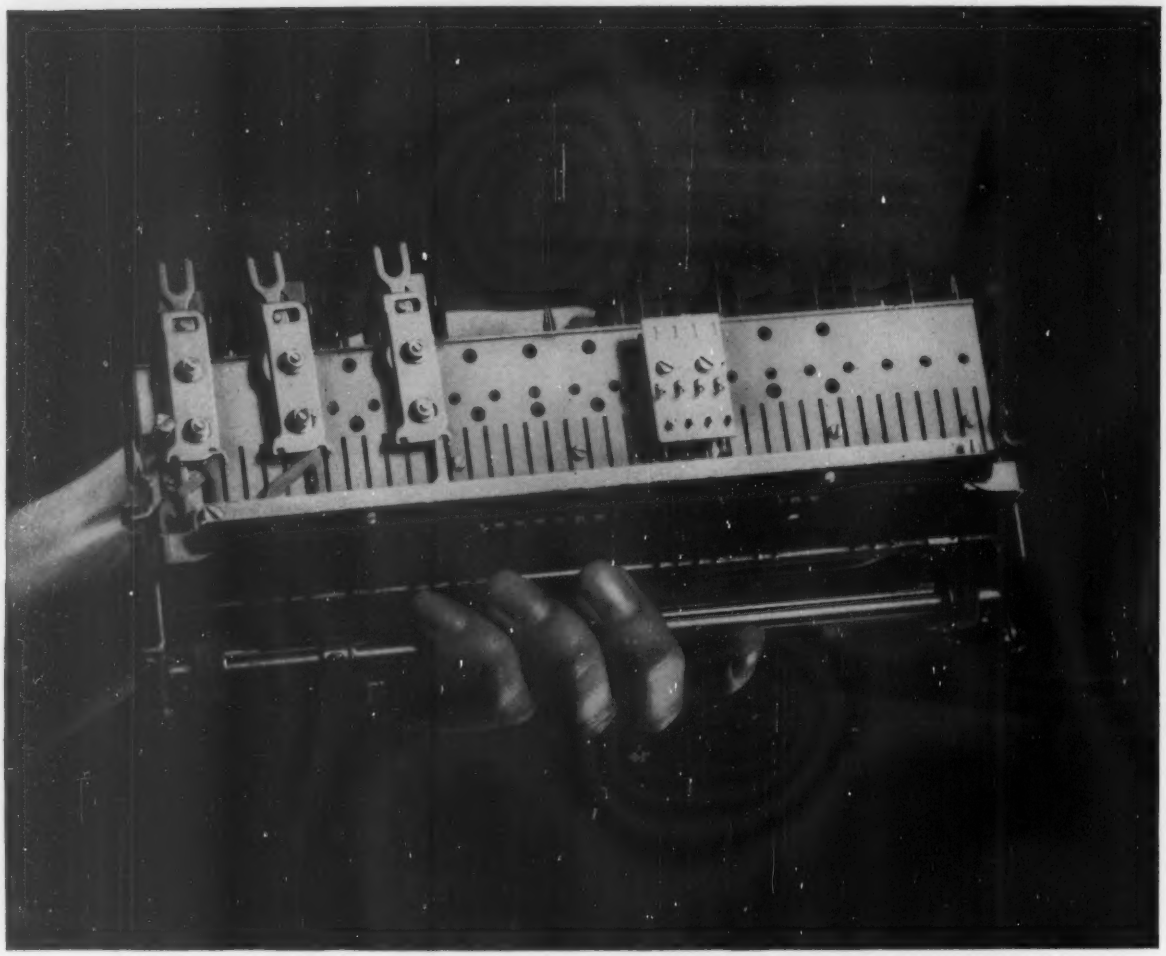
Circle 454 on Page 19



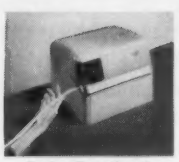
Stunt Box—your Big Plus with Teletype printers

Built into Teletype Model 28 page printers is a control device called the Stunt Box. The function of this unique component is to provide extra control facilities for both local and remote operations. Thus—in addition to transmitting, receiving and recording messages and data—the page printer can be used for a variety of switching, remote control and selective calling tasks.

The Stunt Box reduces costs by simplifying equipment needs and systems arrangements. It is the Big Plus—the extra value in Teletype Model 28 page printers and automatic send-receive sets.

Teletype Corporation manufactures this equipment for the Bell System and others who require the finest in data communications equipment.

Write for free 20-page brochure, "The Teletype 28 Stunt Box," to Teletype Corporation, Dept. 28F, 4100 Fullerton Avenue, Chicago 39, Ill.



Typing Tape Punch

Tape Reader

Send-Receive Page Printer

Automatic Send-Receive Set

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SUBSIDIARY OF *Western Electric Company* INC.

Circle 455 on Page 19

Wherever in the world your hydraulic machinery operates . . .

Shell Tellus Oil is there

Other outstanding Shell Industrial Lubricants available world-wide

- **Shell Rimula Oils**—for heavy-duty diesel engines
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- **Shell Alvania Grease**—multi-purpose industrial grease
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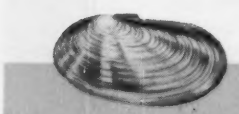
- **Shell Dromus Oils**—soluble cutting oils for high-production metalworking
- **Shell Macoma Oils**—for extreme pressure industrial gear lubrication
- **Shell Voluta Oils**—for high-speed quenching with maximum stability

Around the world, Shell Tellus Oil is available—under the same brand name and providing the same performance that your domestic customers rely upon.

Tellus® Oil is top-rated as both a lubricant and control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge formation, wear and foaming has earned it world-wide popularity.

No matter where your hydraulic machinery is shipped, make Shell Tellus Oil your standard recommendation. Write for complete information.



AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the **Cultellus** costatus.

SHELL OIL COMPANY

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IN CANADA: SHELL OIL COMPANY OF CANADA, LIMITED
505 UNIVERSITY AVENUE.....TORONTO 2, ONTARIO

SHELL

Circle 456 on Page 19

How Fafnir Ball Bearings help spray dryer manufacturer get

Reduced bearing costs with no loss in efficiency

In spray dryers produced by a New Jersey manufacturer for the chemical, pharmaceutical, food, and other process industries, a solution or slurry is fed through a hollow, vertical shaft and centrifuged outward into a drying chamber.

The spray is forced into a wheeling vortex by air heated to 200°F to 1000°F. The hot, turbulent air currents evaporate the water and instantaneously transform the solids into powder. The dried products and air pass from the chamber through a duct to a product collector, after which the air is exhausted to the atmosphere.

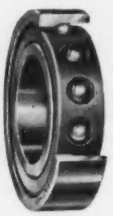
The driving source of the spray dryer is a high frequency induction motor. The motor armature is located between super-precision ball bearings. Drip feed lubrication is employed at both bearing locations. At the lower location, an aspirator prevents lubricant from working out into the machine's drying chamber.

During recent redesigning, the manufacturer called on Fafnir to review proposed bearing specifications. The original design incorporated duplex pairs of super-precision bearings mounted back to back.

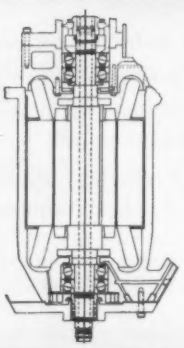
After studying the loading and service conditions involved, Fafnir engineers advised the manufacturer that single, spring-loaded, super-precision bearings, rather than duplex pairs, would provide the necessary capacity, support, and service life. A similar recommendation was made for a new spray dryer unit then under consideration.

Recommendations of the Fafnir engineers were carried out resulting not only in full operating efficiency, but also effecting substantial savings in bearing costs.

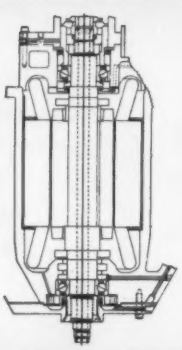
This case history from Fafnir's engineering service files is typical of thousands of ball bearing problems Fafnir has helped solve for manufacturers in every field of industry. For information about the ball bearings described here, or for help with problems you may have, contact your Fafnir branch office nearest you, or write The Fafnir Bearing Company, New Britain, Conn.



Fafnir Super-Precision Ball Bearing — Preloaded, angular-contact bearings, equipped with composition retainers, are widely used in precision-built mechanisms.



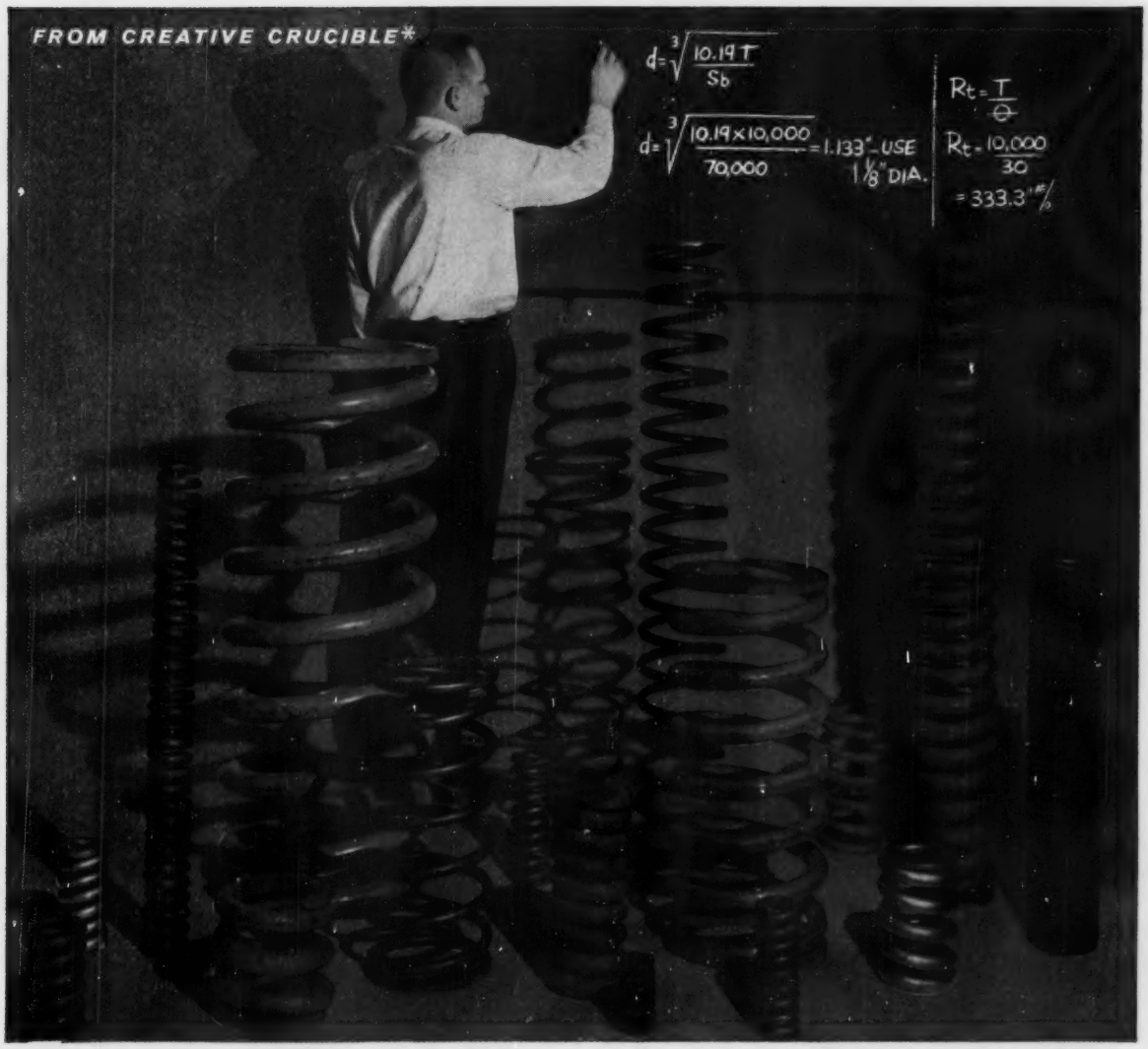
BEFORE
Two duplex pairs of super-precision ball bearings were used to support the high speed shaft of this spray dryer. Redesign specifications called for use of wider type duplex pairs. The change-over was believed necessary for satisfactory shaft support.



AFTER
Fafnir engineers, after a study of loadings and service conditions, advised that a single, super-precision ball bearing at each location would provide ample rigidity. The change resulted in substantial savings at no sacrifice in operating efficiency.

FAFNIR
BALL BEARINGS

Circle 457 on Page 19



Any one of these fatigue-resistant springs will outlast a conventional spring

Yet all of them are competitively priced! Size for size, these heavy-duty, hot-wound springs withstand heavy compressive, tensile or torsional loads—throughout longer periods of service.

Shot peening accounts for the springs' increased endurance. Shot peening imposes a compressive stress on the surface that offsets stresses set up in service. It also "conditions" the surface and eliminates stress concentration points that could lead to premature failure in a conventional spring.

Design Handbook On Coil Springs

But read how you can save space and cut costs with fatigue-resistant springs (the product of Crucible metallurgy from ore to finished spring). Write for the *Heavy Duty Coil Springs* handbook to *Crucible Steel Company of America, Spring Division, McCandless Avenue, Pittsburgh 1, Pennsylvania.*

***HEAVY-DUTY HOT-WOUND COIL SPRINGS** — Crucible makes fatigue-resistant and conventional springs of carbon, alloy, and specialty steels in a wide variety of treatments, from ½" bar size up. Both types are now being used in countless applications in missile launching equipment, freight cars, mining and earth-moving equipment.

CRUCIBLE HEAVY-DUTY COIL SPRINGS

Smaller Control Panels with

CONTROL RELAY
Class 8501
Type DO-22

These 2 UNITS are the basis for a Complete System of relays

TIME DELAY RELAY
Class 9050
Type AO-1E

Here's why designers and users alike prefer Square D...

Complete selection • Relays available for both AC and DC systems—with up to 10 contacts—in both electrically and mechanically held forms. Timing relays with intervals from 0.2 second to 3.0 minutes—also in AC and DC versions.

Require less panel space • Relays are only 3" wide, range in height from 3¼" to 5". Timers are just 2⅝" x 4⅜" or 2½" x 7²½". Mechanically held relays require no extra panel space.

No mounting problems • All Type D relays and Type A timers have identical mounting hole dimensions.

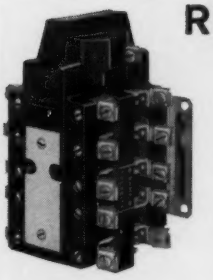
Easy wiring • Choose either pressure wire connectors or slip-on connectors for all terminals.

Long life • Balanced construction reduces wear on single moving part. Epoxy-resin molded coil operates cooler, virtually eliminates coil burnout.

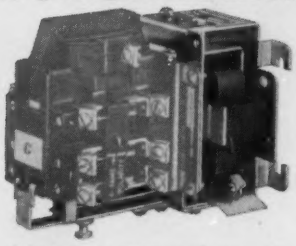
SQUARE D COMPANY

Square D "SYSTEM-DESIGNED" Relays

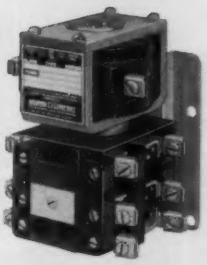
RELAYS FOR EVERY JOB



Square D Type D relays available with up to 10 contacts

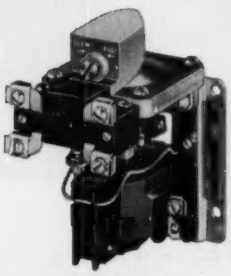


Easy-to-use attachment converts any Type D relay to mechanically held with no increase in panel space

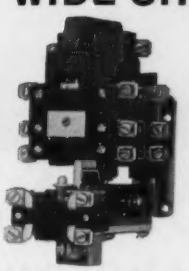


DC relays have mounting dimensions and contact arrangements identical to AC relays

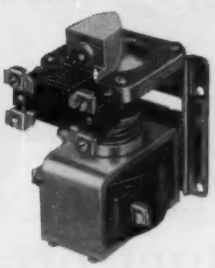
WIDE CHOICE OF TIMERS



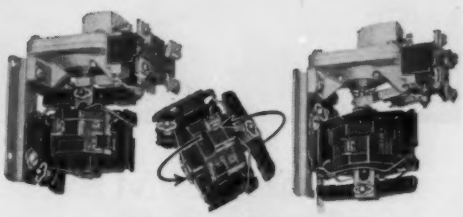
Timing relays have same mounting dimensions as Type D relays



Relay-operated timer

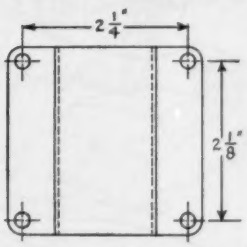


Matching DC timing relays

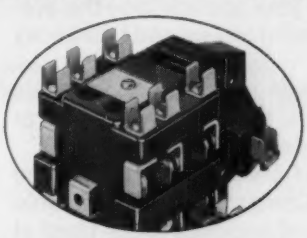


Both AC and DC versions convertible from on-delay to off-delay, using only a screwdriver

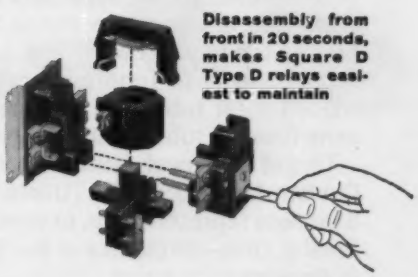
FAMILY FEATURES SIMPLIFY DESIGN PROBLEMS



Mounting dimensions are identical for Type A timers and Type D relays



Slip-on connectors for all terminals available



Disassembly from front in 20 seconds, makes Square D Type D relays easiest to maintain

Write for full details • Ask for Bulletin D, Square D Company, 4041 N. Richards St., Milwaukee 12, Wis.

Square D offers the broadest line of relays, starters and accessories for all types of control systems

Ask your Square D Field Engineer about the new ILO program

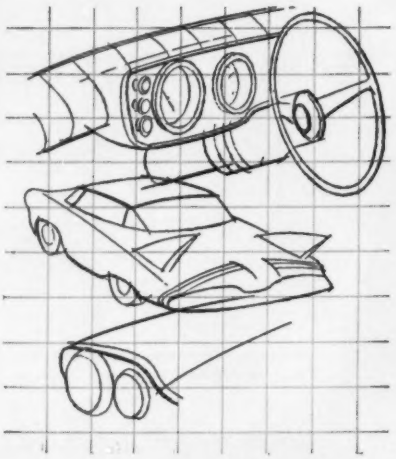
Custom Made OSTUCO Tubing..... gets your product off the ground

OSTUCO tubing is the exact tubing you need for your product because OSTUCO Tubing is CUSTOM MADE for your product. Your order is manufactured to your own specifications to produce steel tubing especially for your application—the precise grade, analysis, size, shape, special anneal and tolerances best suited to your own needs.

Ohio Seamless Tube produces both seamless and electric welded steel tubing—is prepared to form many finished or semi-finished tubular parts to your designs.

To get the most from your next steel tubing order, use Custom Made OSTUCO TUBING. Contact your nearest Ohio Seamless representative, or send part drawings to the plant at Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.

A-2168A



Model illustrated built to 3.5 mm scale.

OSTUCO SHELBY, OHIO

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Division of Copperweld Steel Company • SHELBY, OHIO

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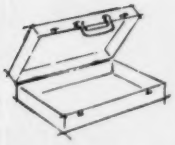
A. O. SMITH HAS THE HORSES...

HURDLE THORNY APPLICATION PROBLEMS



From the case of the A. O. Smith Motor Man

...a line of 800 to 1 hp favorites, built to make tough application problems seem easy

When it comes to building integral-motor-powered equipment, *make sure of your horsepower source!* Before you specify any motor brand, consult with your A. O. Smith Motor Man. He'll show you how the horses of A. O. Smith (single-phase integrals — 1-5 hp — polyphase — 1-800 hp) help users surmount application barriers.

And A. O. Smith delivers the horses that deliver the goods!

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Through research ...a better way

A.O.Smith

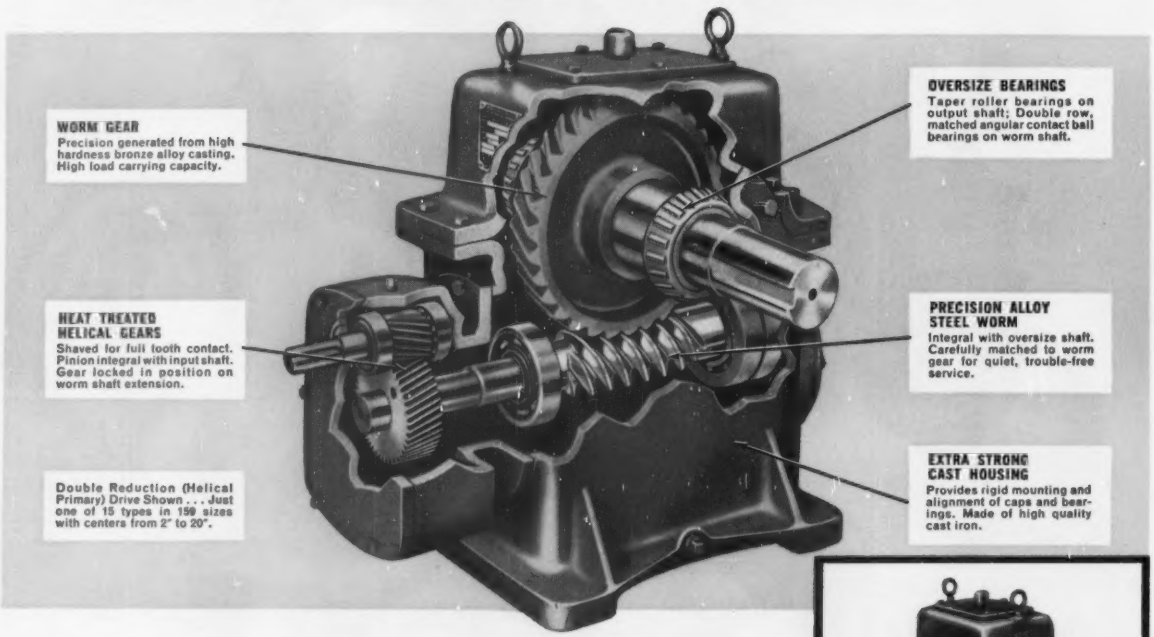
CORPORATION

ELECTRIC MOTORS

Tipp City, Ohio

A. O. SMITH INTERNATIONAL S. A.
Milwaukee 1, Wisconsin, U. S. A.

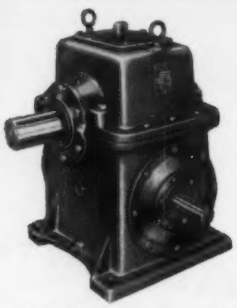
From the ONE COMPLETE LINE of Power Transmission Drives....


WORM GEAR
Precision generated from high hardness bronze alloy casting. High load carrying capacity.
OVERSIZE BEARINGS
Taper roller bearings on output shaft; Double row, matched angular contact ball bearings on worm shaft.
HEAT TREATED HELICAL GEARS
Shaved for full tooth contact. Pinion integral with input shaft. Gear locked in position on worm shaft extension.
PRECISION ALLOY STEEL WORM
Integral with oversize shaft. Carefully matched to worm gear for quiet, trouble-free service.
Double Reduction (Helical Primary) Drive Shown . . . Just one of 15 types in 150 sizes with centers from 2" to 20".
EXTRA STRONG CAST HOUSING
Provides rigid mounting and alignment of caps and bearings. Made of high quality cast iron.

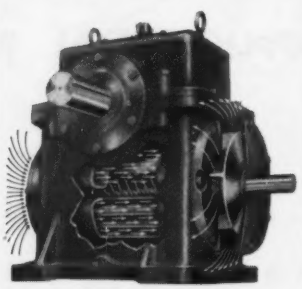
FOOTE BROS. WORM GEAR REDUCERS DELIVER DEPENDABLE RIGHT ANGLE POWER

Gearing is the heart of any drive . . . and because more than 100 years of successful gear design and manufacturing experience go into every Foote Bros. Worm Gear Drive, they have built an unequalled reputation for performance, durability, and operating economy. Foote Bros. Worm Gear Drives are widely used in every industry in applications where dependability is a primary need.

If your drive problems involve right angle, concentric shaft, parallel shaft, or shaft mounted transmission of power, check the advantages of the complete Foote Bros. Power Transmission Line.



SINGLE REDUCTION DRIVES AVAILABLE WITH WORM UNDER OR OVER FOR HORIZONTAL OR VERTICAL MOUNTINGS.



FAN-COOLED SINGLE REDUCTION DRIVES AVAILABLE FOR HORIZONTAL OR VERTICAL MOUNTINGS.

NOW! RATED TO LATEST AGMA STANDARDS

Foote Bros. Worm Gear Drives are rated to the latest AGMA Standards. A new Catalog—HGB—just off the press, illustrates and describes Foote Bros. Worm Gear Drives. Ask your nearby Authorized Foote Bros. Distributor for a copy, or write today.

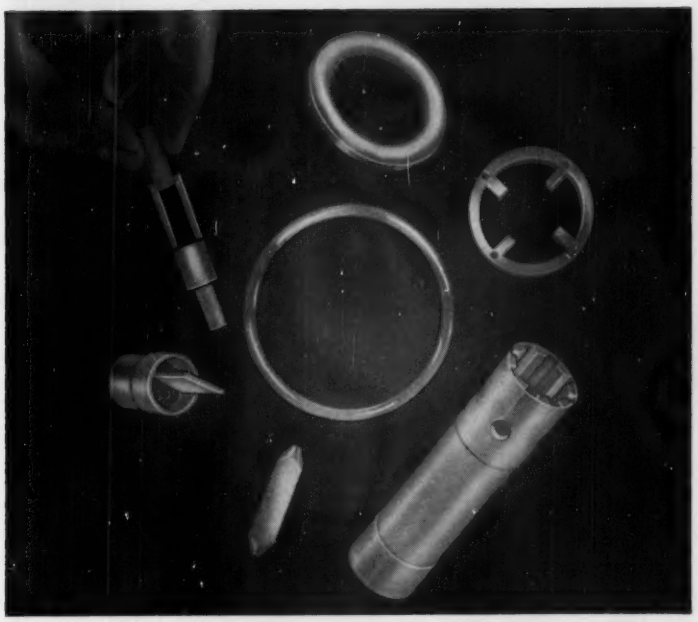
FOOTE BROS. GEAR AND MACHINE CORPORATION

4567 South Western Boulevard, Chicago 9, Illinois

POWER TRANSMISSION DRIVES

Circle 462 on Page 19

PLASTICS
in Design
Engineering



New Teflon* FEP resin enables Garlock to supply mechanical and electrical parts of complexities never before achieved.

New developments in TEFLON FEP shapes and parts by Garlock. With the commercial availability of Teflon FEP, Garlock can now fabricate mechanical and electrical components never before possible with Teflon TFE. The reason is this—whereas TFE must be processed like powdered metals, the new FEP has the advantage of being melt-processed in conventional extrusion and injection molding equipment.

Think of what this means to you as a designer. You can now specify Teflon for the most delicate and complex shapes you may design. Teflon FEP opens whole new avenues of design possibilities . . . parts of the most intricate shapes . . . wall sections of minimum thinness of .020″-.030″ . . . pieces with the closest of tolerances. Garlock also furnishes Teflon FEP in rod stock for ready cutting and machining.

Another important point. Developed as a supplement to Teflon TFE, the new FEP resin exhibits the same fine physical properties of chemical inertness, top thermal stability, excellent dielectric strength, and outstanding anti-stick and frictional characteristics. FEP is rated at a continuous service ceiling of +400°F, will resist extreme cold down to −395°F.

At low temperature, FEP has more impact resistance than any other known plastic. It is virtually unaffected by weather and remains unchanged when subjected to ultra-violet light and ozone attack. Finally, water absorption of FEP is zero!

Turn to Garlock—and their years of experience in fabrication of plastics—for more information on stock shapes and intricate parts of new Teflon FEP. The Garlock representative serving you will be glad to give you complete details. Call him at the nearest of Garlock's 26 sales offices throughout the U.S. and Canada. Or, write for catalog, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

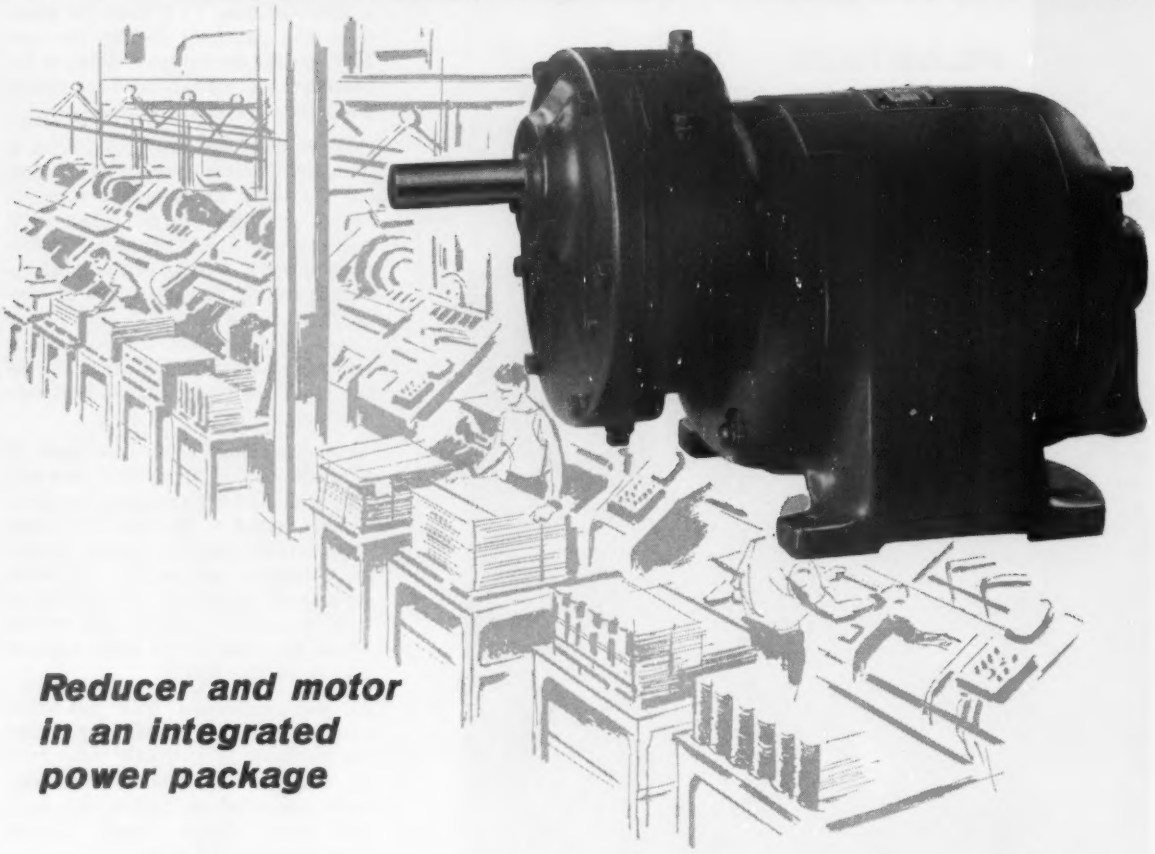
Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

*Du Pont Trademark for TFE and FEP resins

Circle 463 on Page 19

MASTER GEARMOTORS

save material, space and money



Reducer and motor in an integrated power package

Particularly suited to low speed applications, this Master Gearmotor gives you a highly efficient, self-contained unit that saves you money in a lot of ways:

1. Reduces mounting plate size.
2. No V-belts, chains or sprockets required.
3. Takes up less space.
4. No separate components—just one compact unit.
5. No high speed coupling, or gear and motor alignment.

Master Gearmotors are available not only in open, enclosed and explosion-proof types, but can be supplied with an electrically operated Master Unibrake Motor—ideal where quick stopping or positive holding is necessary.

Ratings are from ⅛ to 125 hp.; reduction ratios up to 120:1. You get a maximum choice of mountings: vertical, horizontal or flange; fluid couplings are available for hard-to-start or cycling loads.

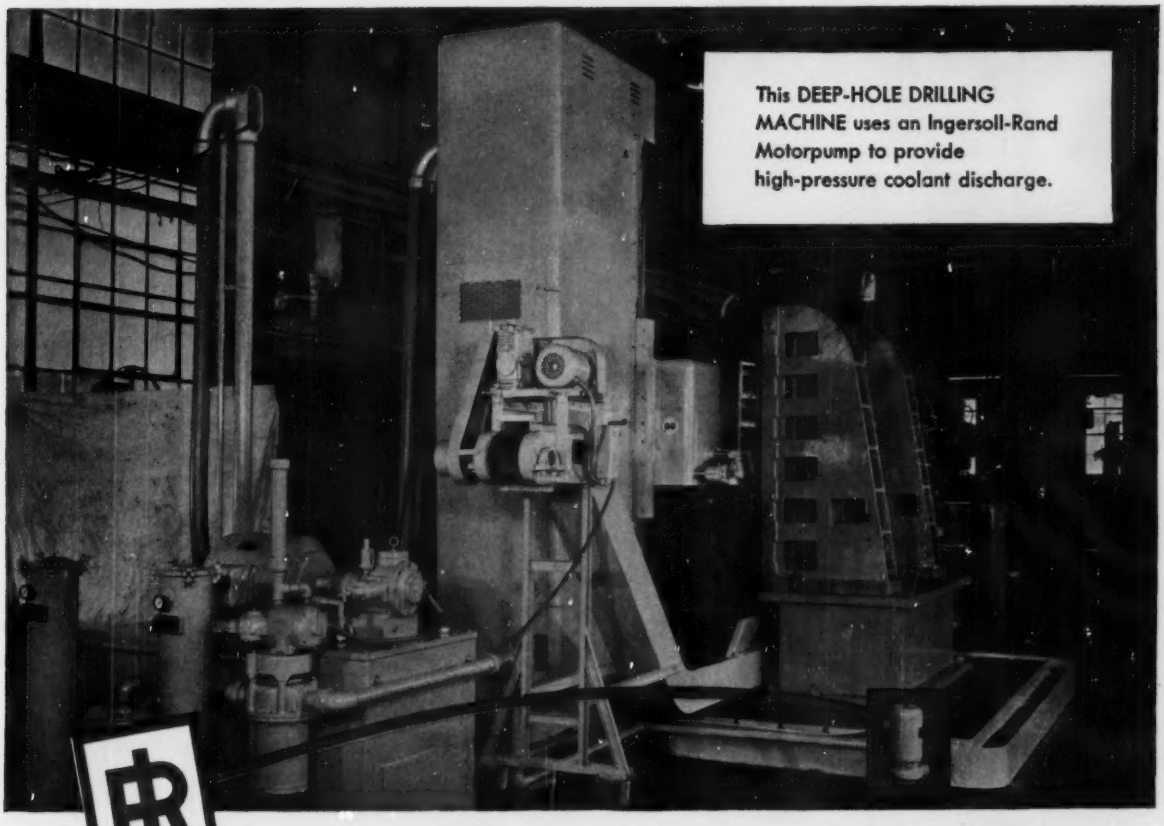
Your Reliance Sales Engineer can give you all the facts about the broad line of Master Gearmotors: parallel, and right angle, as well as in combination. Call the nearest Reliance office for application help, or write for price and rating information. E-1658

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 286A, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in Principal Cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.



solves pumping problems for equipment designers

Ingersoll-Rand today offers machine builders and equipment designers the widest possible choice of pump models. Ingersoll-Rand can solve your liquid-movement problems and meet your specifications exactly or we will design and build the pump you need if existing models can't be fitted to your requirements!

Check with Ingersoll-Rand today. The pump specialist at your nearby I-R branch office is always ready to help, or write for catalog data.

a century 1860 – 1960 *of pump progress*

from the leading manufacturer . . .

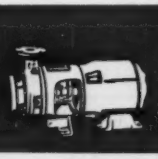
Ingersoll-Rand

11 Broadway, New York 4, N. Y.

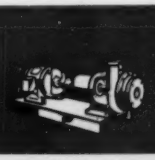
145A9

Immersion and sidewall mounted Motorpumps
¼ through 20 hp delivery to 1000 gpm
heads to 170 ft

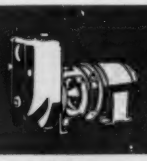
OTHER I-R PUMPS AVAILABLE



Motorpumps

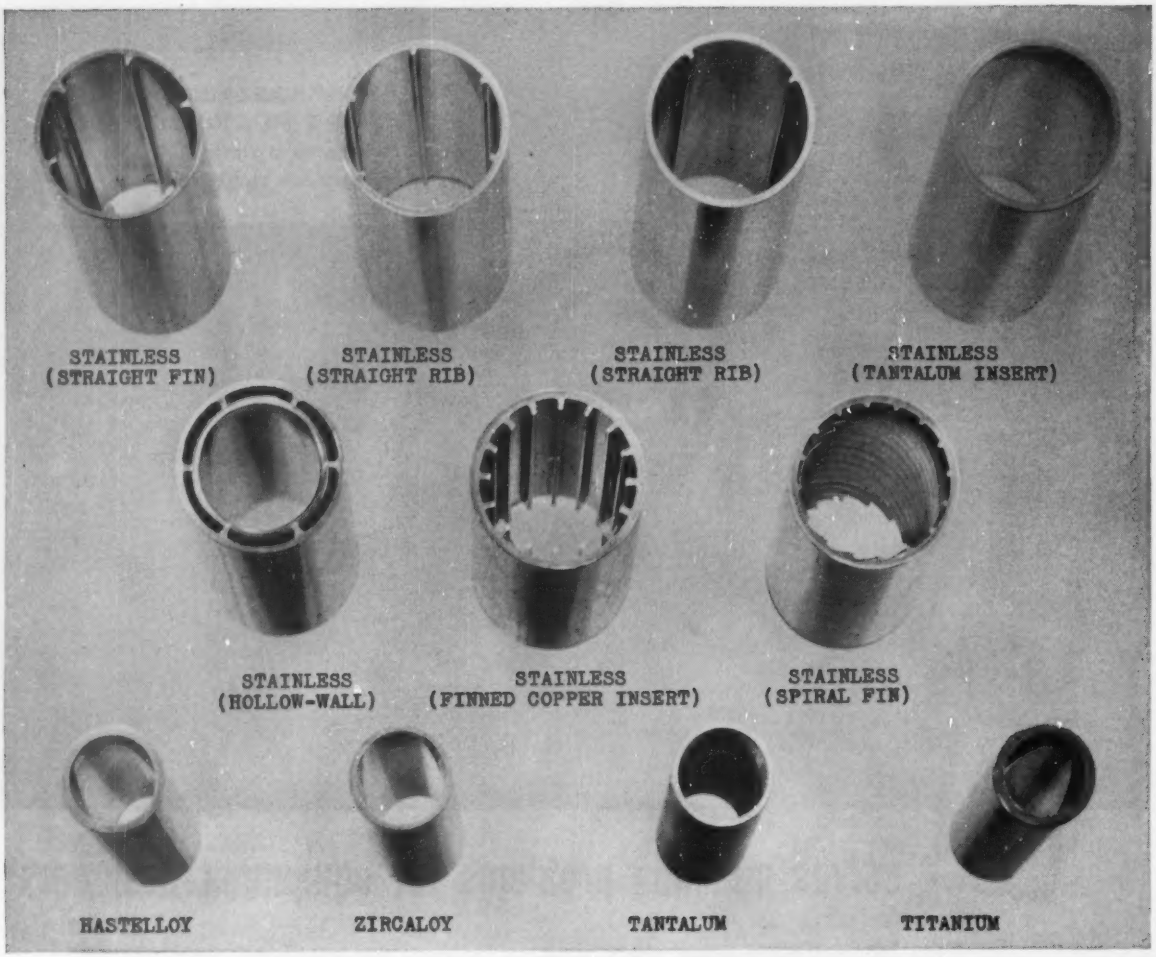


Cradle-Mounted Pumps



Self-Priming Motorpumps

Horizontally-Split Pumps



ALL OF THESE TUBES WERE PRODUCED by a remarkable new process called FLO-ROL

Tubes like these have never been economically available before. The entirely new process, known as FLO-ROL, will produce a wide variety of internal configurations, in high cost alloys, stainless steel, and other hard-to-work metals, plus many bi-metal and tri-metal combinations. Wall tolerances for FLO-ROL tubing can be held to ±.0005" and diameters to ±.002" depending on sizes.

- *Internally Finned Tubes* offer increased surface for more rapid heat transfer.
- *Bi-Metal Tubes*—stainless steel tubes with tantalum, zirconium, or other expensive material offer exceptional corrosion-resistant qualities without the prohibitive cost.
- *Hollow Wall Tubes* or barrier tubes are available in several designs for nuclear work or other special applications where a chambered tube is essential or desirable.
- *Thin Wall Tubes* for pneumatic lines are available with .015" wall or lighter.

FLO-ROL precision tubular products can be furnished from ½" to 2½" O.D. and, in some instances, in lengths up to 75'. For complete information contact your nearest Damascus representative or write direct. For prompt service send prints and specifications—we will be happy to work with you.

Send for new FLO-ROL PRECISION TUBE BULLETIN TODAY

DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE

GREENVILLE, PENNSYLVANIA

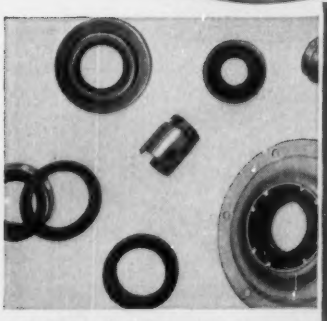
Chicago-Allis

One source service for custom molded rubber—seals—leather products...

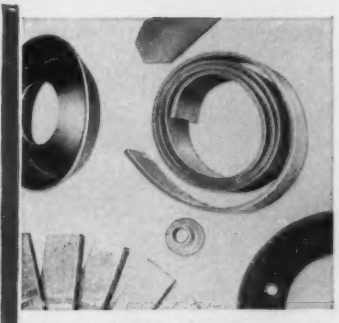
This temperature regulating application is typical of the many thousands of different custom molded rubber products Chicago-Allis has created to meet specific customer requirements.

(1) By utilizing the flexibility and high temperature resisting characteristics of silicone rubber, plus the strength of nylon for reinforcement, a highly successful valve diaphragm was produced. **(2)** To create the very efficient valve seat shown here, Chicago-Allis designed and bonded an impervious rubber to a brass stem.

In providing rubber parts like these, Chicago-Allis not only molds from scientifically formulated and compounded polymers but assists in the design and development of the customer's own product in order to achieve the maximum in performance for the entire unit.



Custom seals that meet maximum uniformity and quality standards, designed and manufactured to perform specific functions. Will operate under all conditions. Made in both shaft and face types.



Chicago-Allis is fully equipped to design and manufacture all types of hydraulic, vacuum and pneumatic packings, leather transmission belting, textile and mechanical leathers. Let us prescribe the leather part best suited to your needs.

If you purchase molded rubber parts, shaft or face type seals, packings, mechanical leathers, or power transmission belting, Chicago-Allis offers you one source service. Our complete laboratory, engineering, and manufacturing facilities combine efforts to produce the finest quality products designed especially for **you.**

More than 66 years of experience have enabled our technicians to go directly to the heart of every design problem in the least possible time to produce the most efficient and economical parts.

There's a Chicago-Allis representative in your area, willing and anxious to serve you. Call him or write direct. We will be glad to supply you with a catalog which completely describes our products and services.

"Chicago-Allis Engineers to your Specifications"

SINCE 1889

CHICAGO-ALLIS MFG. CORP.

Producers of CHICAGO BELTING • ALLIS RUBBER • ALLIS SEAL Products

137 NORTH GREEN ST. CHICAGO 7, ILLINOIS

Engineers • Designers • Manufacturers

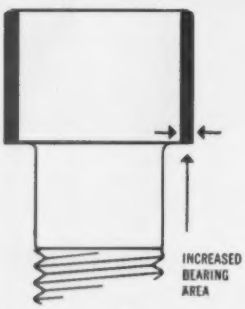
Circle 467 on Page 19

Up to 2⅓ times as much holding power!

Up to 100% longer fatigue life!

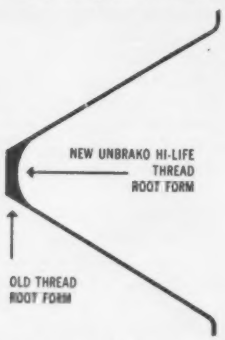
New UNBRAKO *pHd** Hi-Life socket screws —the advanced-design fastener for the 60's

Stronger in the head



New pHd head features increased bearing area, more powerful wrenching socket; provides up to 2⅓ times as much clamping force without indenting bolted material. This permits higher preloading, which in turn helps prevent fatigue failures or loosening under vibration.

Stronger in the thread



Smoothly radiused root of new Hi-Life thread distributes stress concentrations at point where 85% of screw failures occur. Elimination of sharp root corners practically doubles fatigue life, yet new thread fits standard tapped holes and nuts, requires no special gaging.

Here is the one new socket head cap screw that is redesigned *throughout*. UNBRAKO pHd Hi-Life is the only standard socket screw offering you both the new, larger pHd head (1960 Series) *and* new UNBRAKO Hi-Life thread—a combination unequaled for strength and performance.

Because of its increased bearing area under the head, you can tighten a pHd Hi-Life tighter without indenting the bolted material. This safeguards vital preload; protects against loosening under shock or vibration. At the same time, the new Hi-Life thread form drastically reduces stress concentrations at the root, where the majority of screw failures occur. Result: up to 100% increase in fatigue life.

Both the pHd head and Hi-Life thread originated in the SPS laboratories for advanced fastener research where they were first developed for ultra-high-strength aircraft bolts. Recognizing the critical need for increased mechanical reliability in industrial and consumer goods as well, SPS now offers these refinements in a standard commercial fastener. Price? The same as previous UNBRAKOs. Availability? Immediate—in sizes ¼ through 1 inch. See your authorized industrial distributor or write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium. Request Bulletins 2406, 2577.

TENSION-TENSION FATIGUE TESTS PROVE LONGER FATIGUE LIFE OF UNBRAKO HI-LIFE THREAD FORM

Screw Size: ½-20 Testing Speed: 1050 cpm

Alternating Stress in psi (000 omitted)	Cycle Life: Old Thread Root Form	Cycle Life: UNBRAKO Hi-Life Threads
2-20	2,076,000	8,000,000*
3-30	598,000	1,808,000
4-40	120,700	232,350
5-50	56,650	89,950
7-70	22,900	40,000

*Test stopped—no failure

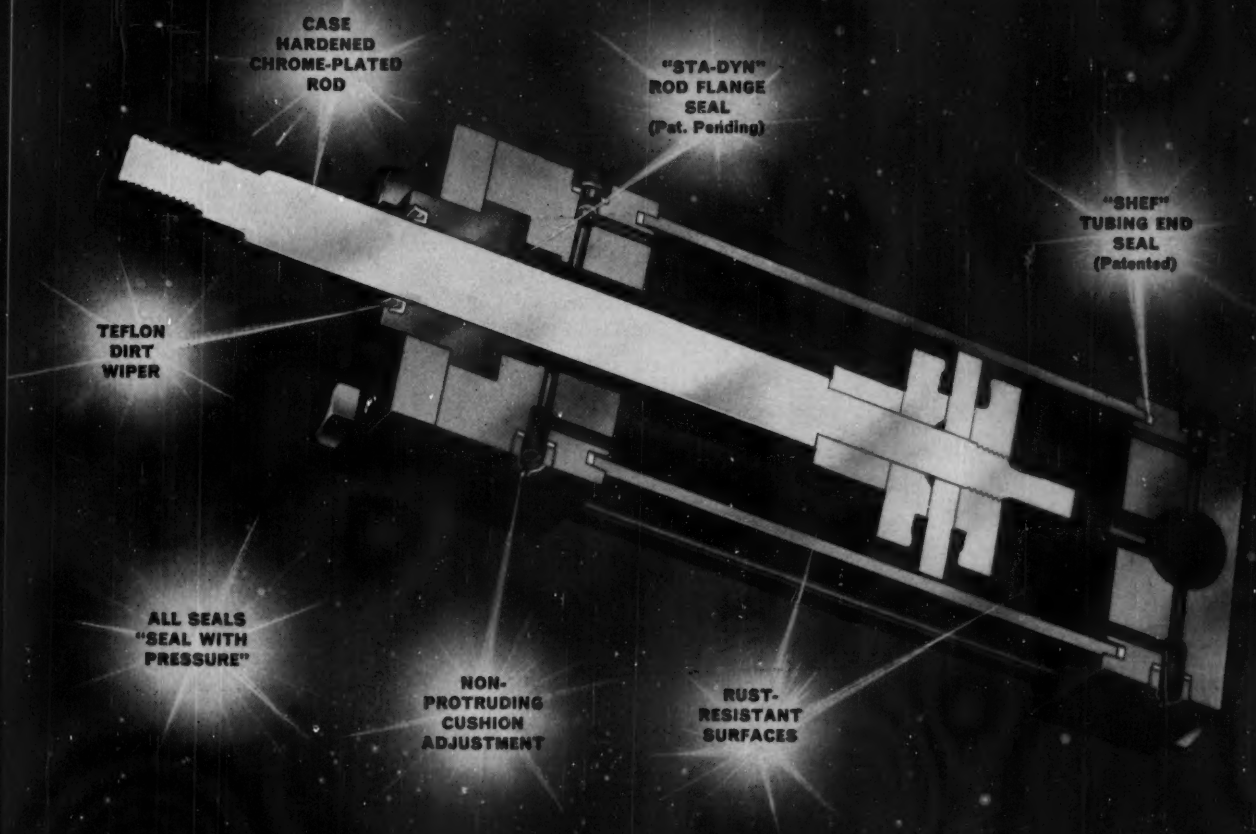
INDUSTRIAL FASTENER Division

JENKINTOWN 18, PENNSYLVANIA **SPS**

where reliability replaces probability

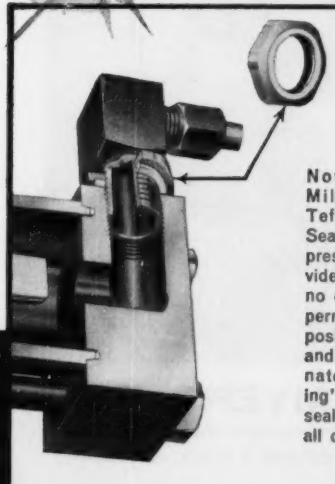
*pHd stands for "proper head design"—a factor in higher product reliability

Stellar RELIABILITY and ECONOMY


CASE HARDENED CHROME-PLATED ROD
"STA-DYN" ROD FLANGE SEAL (Pat. Pending)
"SHEF" TUBING END SEAL (Patented)
TEFLON DIRT WIPER
ALL SEALS "SEAL WITH PRESSURE"
NON-PROTRUDING CUSHION ADJUSTMENT
RUST-RESISTANT SURFACES

Miller AIR CYLINDERS

PORT SEALS



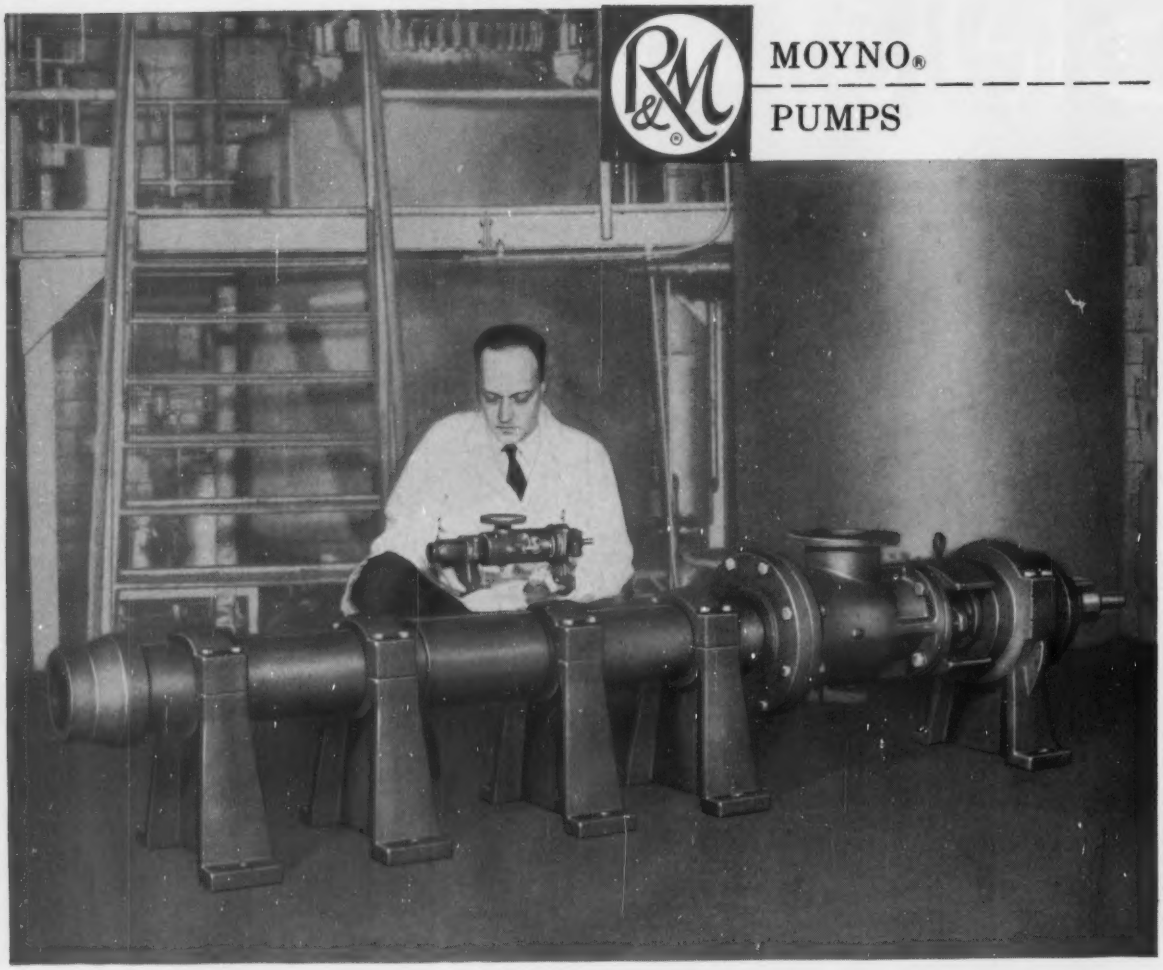
Now—with every Miller Cylinder—Teflon-sealed Port Seals that "Seal with pressure" are provided as standard at no extra cost. They permit much faster positioning of lines and fittings, eliminate "overtightening" damage, and seal perfectly against all operating media.

Here are eight more reasons why Miller Air Cylinders continue to be the most economical and reliable cylinders that money can buy. These stellar features—including the new port seals—are standard Miller construction—yours at no extra cost. Thus, they provide appreciable savings in original investment—*particularly for those who insist on "J. I. C." quality throughout.* Savings in operating costs are even greater, because these features are proven assurance of longer cylinder life, greater efficiency, reduced maintenance and downtime.

Specify "Miller" for greater reliability and economy! Write for bulletin.

MILLER FLUID POWER

7N016 YORK ROAD, BENSENVILLE, ILLINOIS



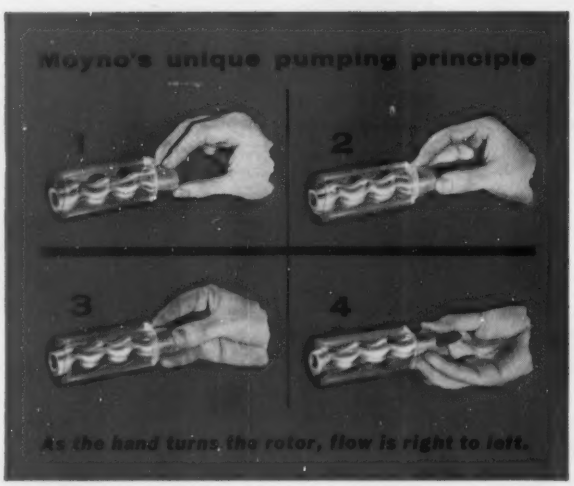
MOYNO®
PUMPS

MOYNO® PUMPS *capacities: from 1/100 to 500 gpm pressures: up to 1000 psi*

MOYNO pumps are available in nine sizes with capacities ranging from minimum metering flow to 500 gpm and pressures from zero to 1000 psi. Positive displacement delivers uniform discharge without pulsation, agitation or turbulence. Solutions ranging from thin watery slurry to extremely viscous paste, corrosives, abrasives and even solids in suspension are economically handled without excessive pump wear.

MOYNO'S unique *"progressing cavity"* principle with only one moving part and special resistant internal parts slashes pump maintenance costs on problem materials that often ruin other pumps. Almost any substance that can be forced through a pipe can be pumped by a MOYNO.

To learn how a MOYNO can cut your pumping costs, write today for Bulletin 30-MD



ROBBINS & MYERS, INC.

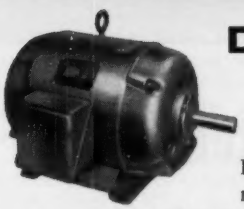
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Circle 470 on Page 19

MOTORS

1 thru 200 horsepower
(other ratings 1/200 to 1 h.p.)

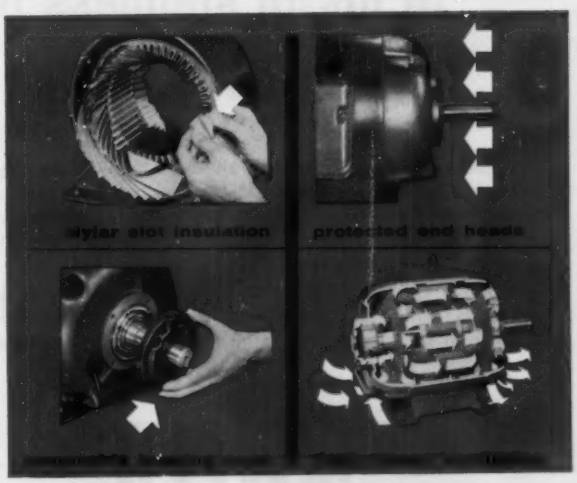


Double Width Bearings Hold More Grease...*Insure Longer Motor Life!*

Bearings in ROBBINS & MYERS motors run in double-width races with extra-large lubricant reservoirs. Bearings are fully sealed and pre-lubricated with laboratory tested grease which resists dust, temperature, humidity and high operating speeds. Tests prove these bearings can withstand six to nine years of severe service without relubrication. Bearings are further protected by metal seals on each side. Seals keep impurities out, prevent failure caused by "forgotten" lubrication or damaging over-lubrication.

R&M insures longer motor life with many additional features: Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . removable caps for quick bearing inspection and relubrication . . . end heads that give full-height protection . . . dual-sweep ventilation for efficient cooling. For details, write today for Bulletin 520 MD

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

18 lbs. of stainless per ring eliminated by flash butt-welding extruded sections

Amweld experience in forming and flash butt-welding rings from extruded sections reduced the cost of $52.00 rings to $21.00 each. A special section closely approximating the cross-section of the finished part was selected to replace heavy rectangular bar stock. By leaving over 12,000 lbs. at the mill, the cost of these rings was reduced by 40%—not to mention large savings in machining time.

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and machining facilities, phone or write.

GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

Circle 472 on Page 19

Cedarapids Super Commander Portable Crushing and Screening Plant, built by Iowa Manufacturing Company, Cedar Rapids, Iowa, produces up to 500 tons per hour of crushed and screened material in four different product sizes.

This high capacity V-Belt Drive handles

60% more power in 30% less space!

Higher Capacity of Gates Super HC V-Belt Drives solves complex product-development problem!

In developing a larger crusher, requiring more horsepower, Iowa Manufacturing Company was faced with the problem of transmitting 400 hp from a higher-speed engine in a space that had been just enough for conventional V-belts carrying 250 hp.

At the higher speeds, centrifugal force made it impossible to go to larger sheave diameters to accommodate larger belt sections. A wider span of belts was ruled out by Highway Department requirements, which restricted overall machine width to eight feet.

Iowa Manufacturing's designers solved their primary problem of transmitting 60% more horsepower with new Gates Super HC V-Belts.

Because Super HC V-Belts have smaller cross section, use narrower and lighter-weight sheaves, pack higher hp capacity in a smaller 'package' than conventional V-belts, designers also succeeded in reducing drive weight, width and height — a decided bonus in equipment that must be moved frequently both on and off the highway.

Nation-Wide Engineering Service

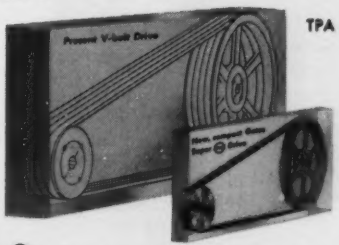
Your nearby Gates Representative can show you how to reduce drive weight, space and cost with Super HC V-Belt Drives. With Super HC, sheave diameters can be reduced 30% to 50%, drive space up to 50%, and drive weight 20% or even more.

Ask your Gates Representative for your free copy of "The Modern Way to Design Multiple V-Belt Drives," or write to The Gates Rubber Company Sales Division, Inc., Denver, Colorado.

The Gates Rubber Company, Denver, Colorado

Gates Rubber of Canada Ltd., Brantford, Ontario

Gates *World's Largest Maker of V-Belts*



TPA 503

Gates Super HC V-Belt Drives

same hp capacity in smaller "package"

Circle 473 on Page 19

Do you check these points When Buying **STAINLESS STEEL** *Valves?*

- ☐ **How good are the castings?**
- ☐ **How precise is the machining?**
- ☐ **How rigid are the inspection and testing?**
- ☐ **How sound is the design?**

Just as important as a suitable stainless steel alloy are these four checks on valve quality. For long, dependable performance, a valve should rate *perfect* on every one.

There's a very good reason why you can be sure Jenkins Stainless Steel Valves will do that, unvaryingly:

For almost a century Jenkins has specialized in making valves. And making them to one standard of quality . . . the highest. Every operation and every worker is aimed at fulfilling that standard. The result is a product that can be backed by this 91-year-old assurance for valve users:

A Fair Offer

If you will put a Jenkins Valve, recommended for your particular service, on the worst place you can find . . . where you cannot keep other valves tight — and if it is not perfectly tight or it does not hold steam, oil, acids, water or other fluids longer than any other valve, you may return it and your money will be refunded.

Order these reliable Jenkins Valves from your local Jenkins Distributor. Ask him or write us for Stainless Steel Catalog No. 59SS. Jenkins Bros., 100 Park Avenue, New York 17.

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
JENKINS SINCE 1864 Jenkins Bros

Sold Through Leading Distributors Everywhere

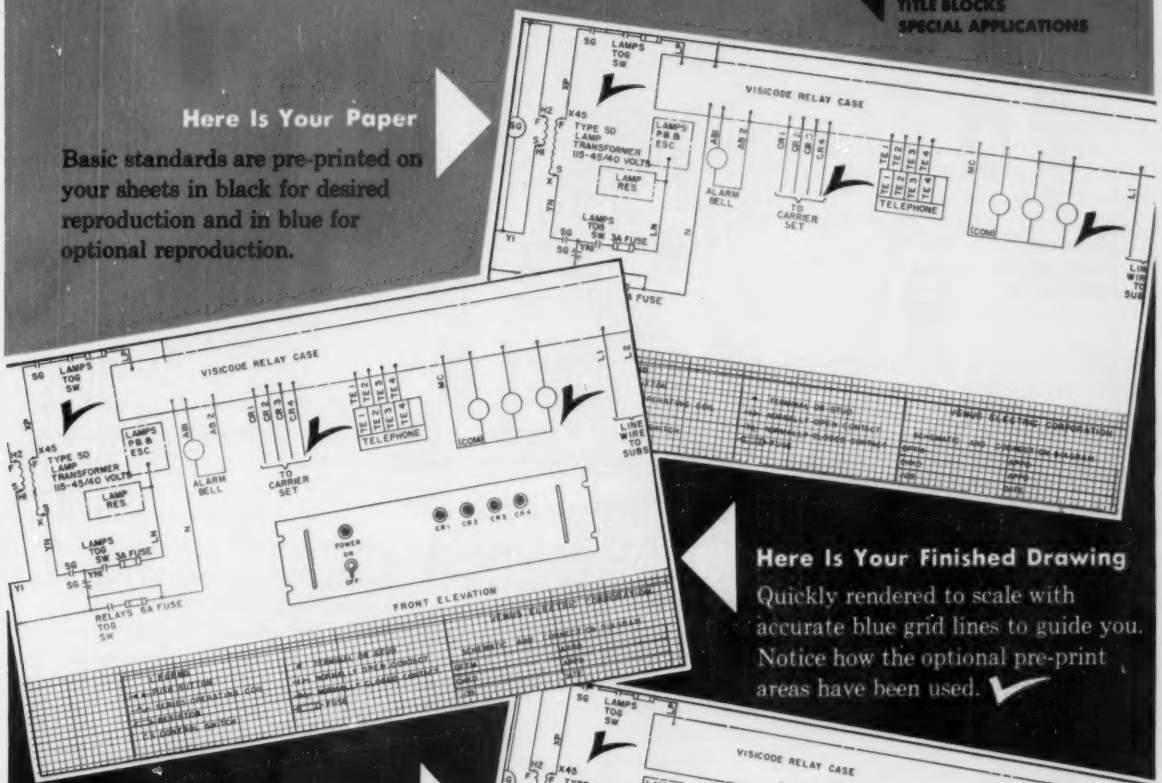
SAVE DRAFTING TIME WITH CLEARPRINT® "FADE-OUT PRE-PRINT" FORMS

PRE-PRINTED

- TYPICAL DETAILS
- BASIC STANDARDS
- BILLS OF MATERIALS
- TITLE BLOCKS
- SPECIAL APPLICATIONS

Here Is Your Paper

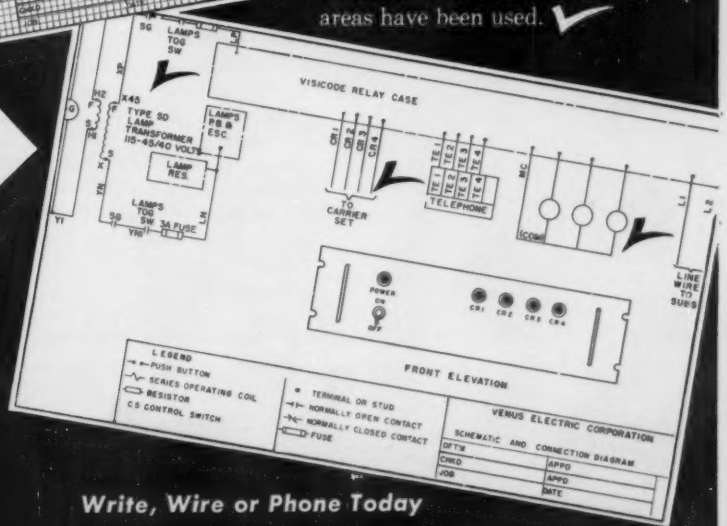
Basic standards are pre-printed on your sheets in black for desired reproduction and in blue for optional reproduction.



Here Is Your Finished Drawing

Quickly rendered to scale with accurate blue grid lines to guide you. Notice how the optional pre-print areas have been used.

Here Is Your Finished Print



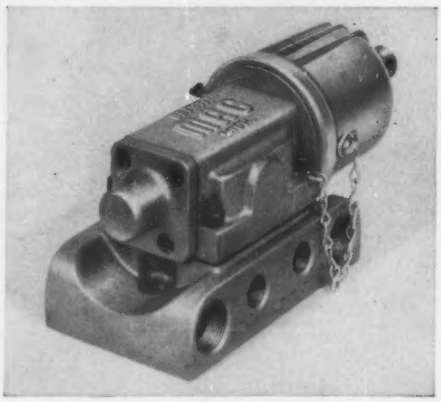
Write, Wire or Phone Today

New Solenoid Air Valves Need No Accessories

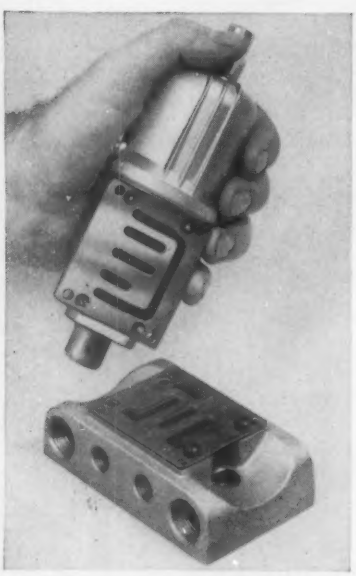
Now available for the first time are solenoid operated air valves complete with all accessories at 'bare valve' prices. Available in ¼, ⅜, and ¾ in. port sizes, they come in single- and double-solenoid types in 3-way, 4-way and 4-way 5-port models.

Features include: solenoids interchangeable on all models of a given size; pre-wired plug-in type bases, eliminating customary wiring; standardization of bodies and bases for interchangeability; unusual compactness; elimination of troublesome fasteners in solenoid assembly (which floats in rubber).

All valves are equipped with screwdriver or ball type manual solenoid operators with lock-in and lock-out feature.



Manifold type bases with common inlet exhaust, and conduit, available on ¼ in. models. For complete information, ask for MAC catalog #60.

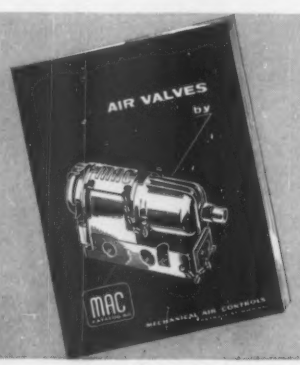


Plug-in Connectors Now Standard on All MAC Solenoid Valves

Pre-wired bases, into which you simply plug in the valve body, are now standard on all MAC solenoid valves—both direct-solenoid and solenoid-air types. Bases are identical for single- and double-solenoid valves of a given size.

The same principle is also applied to the "add-a-unit" manifold type bases available for all MAC solenoid valves. With these, from 2 to 10 valves can be coupled with common inlet, exhaust and conduit. Individual valves can also be isolated or pressure fed in from each end.

With plug-in leads provided on all solenoids, wiring of valves has been reduced to the utmost in simplicity.



NEW

Write today for this free air-valve manual and catalog.

You'll be surprised at how much time it will save you in picking just the right valve for your application. Ask for Catalog #60.

advances in
PNEUMATICS

MAC

evolution of valve seals...

While metal-to-metal seals work well in hydraulic valves, where inherent leakage is accepted, positive leakproof sealing is mandatory in air valves. Flexible seals are today accepted as vital and they must be so designed that sealing efficiency increases with pressure. The seal should be self-cleaning so that foreign matter won't cause leakage.

At one time O-rings were thought to be the answer. O-rings are excellent for static sealing or where travel is short. O-rings are unsatisfactory, however, when used as valve seals crossing an orifice due to the shearing action.

Developing the best design and compound for air-valve seals was a long and tedious job, since elasticity, durometer hardness, compression set, and co-efficient of friction are also important factors.

Experience to date has proven that the best valve seal is a special Buna-N base self-lubricating oil-resistant compound—bonded to the metal to keep it from distorting.

This is the type of seal used in MAC valves. We believe it represents an ideal combination. At least, their amazingly long life in MAC valves seems to confirm that belief.

A. D. Lindsay

President

MAC

MECHANICAL AIR CONTROLS, INC.
10030 Capital, Oak Park • Detroit 37, Michigan

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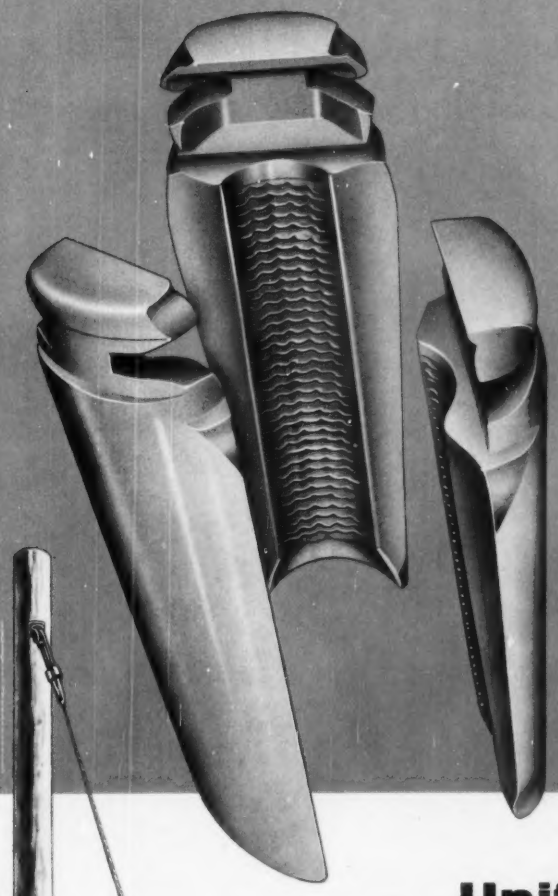
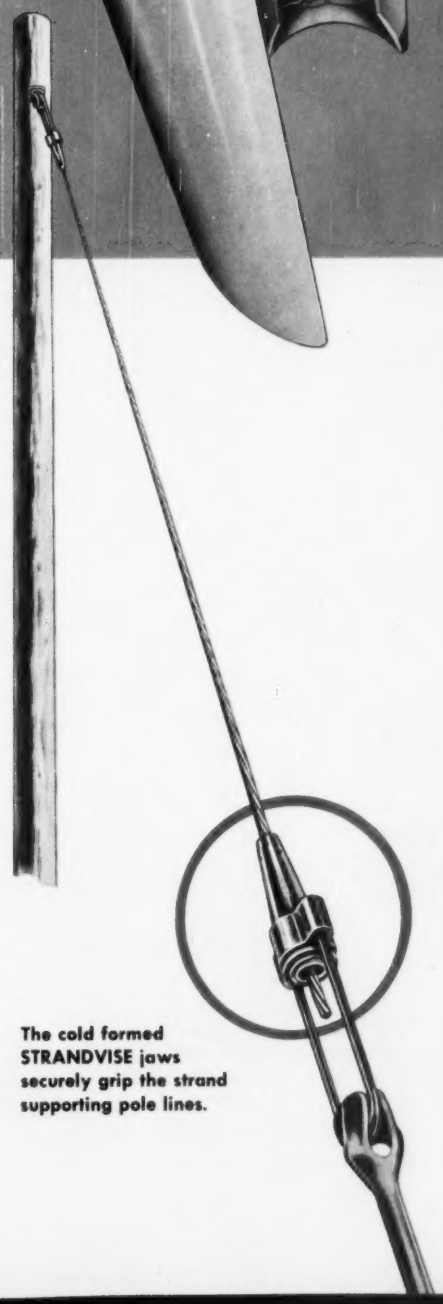
Circle 477 on Page 19→

10 STAGE COLD FORGING

KEYSTONE FORGING WIRE WIRE STUDY

Reliable ELECTRIC COMPANY
Franklin Park, Illinois





The cold formed STRANDVISE jaws securely grip the strand supporting pole lines.

Uniform KEYSTONE WIRE meets the demand . . .

Cold formed jaws that clamp together in a "death grip" hold the strand securely when tension is applied — this is the secret of Reliable's remarkable STRANDVISE®. And the secret of producing quality jaws successfully is Keystone Wire!

The jaws are formed in ten cold forging steps — finish is micro-checked to a tolerance of ±.0015 on smallest chucks. Such rigid requirements challenged Keystone metallurgists to combine the right wire qualities — flowability for extreme forming, uniform temper and close control of diameter on a wide range of sizes. Keystone Forging Quality Wire continuously performs this intricate die forming job, eliminating rejects and waste previously experienced . . . making jaws that will not fail — sharp teeth that bite in and hold. We're proud to have helped Reliable find the solution to a complicated forging operation. We'll be glad to help you, too! Invite your Keystone representative in today for a discussion of your wire problems.

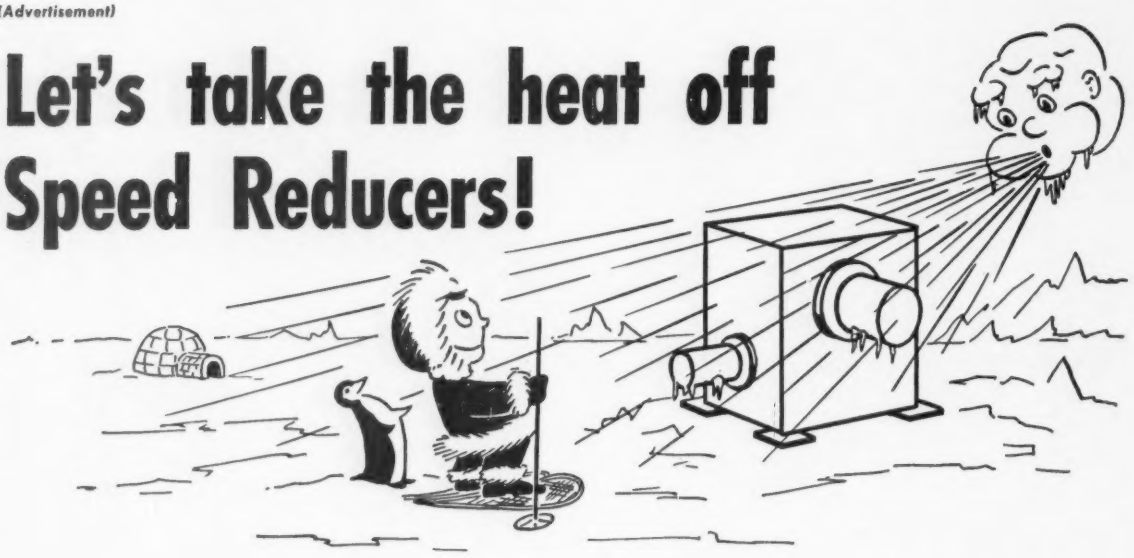
Keystone Steel & Wire Company, Peoria 7, Illinois

KEYSTONE

WIRE FOR INDUSTRY

(Advertisement)

Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

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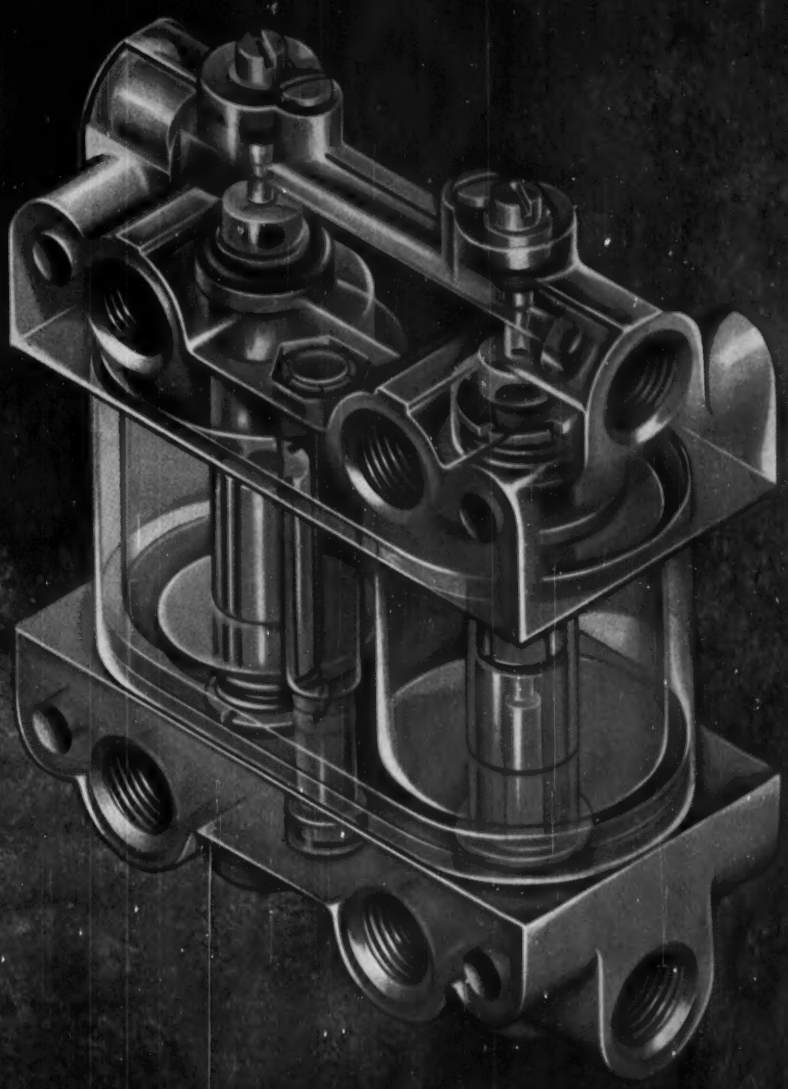
Circle 479 on Page 19→



Compact 4-way

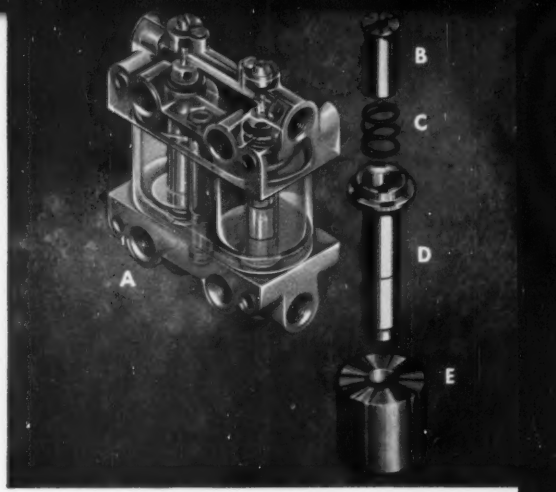
SKINNER

Solenoid Valves

assure precise cylinder control

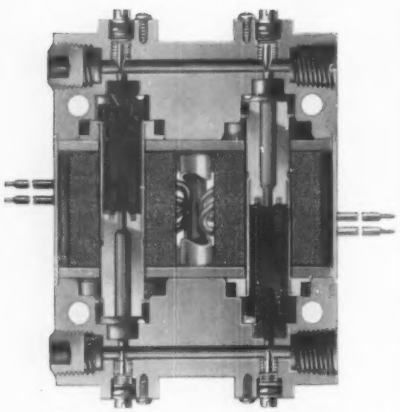
Here's how accurate, dependable operation is built into SKINNER 4-way solenoid valves

- **Precise flow control**—by adjustable metering
- **Compact, direct acting**—two 3-way valves in one housing
- **Durable and corrosion resistant**—stainless steel internal parts
- **Leakproof, bubbletight sealing**—soft, synthetic inserts
- **Positive operation mounted in any position**—spring-loaded plungers
- **Underwriters approved**—wide selection of coils, voltages and frequencies
- **Wired from front or rear**—housing easily reversed
- **Adaptable to many uses**—optional porting arrangements



A. Transparent view of 4-way solenoid valve B. Plunger C. Plunger return spring D. Sleeve E. Coil

SKINNER four-way solenoid valves available in three basic types



The Skinner V9 solenoid valve is two 3-way valves in one compact housing. Both valves may be independently controlled and metered to provide accurate, dependable control of single- or double-acting cylinders, or larger pilot-operated valves.

V9 types are available without adjustable flow and with metering at both exhaust ports, both inlet ports or full metering of all ports.

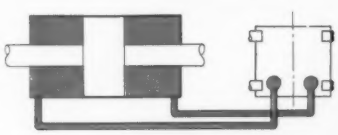
▪ ▪ ▪

For complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

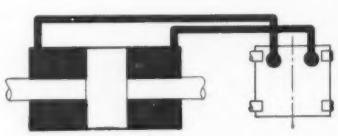
V9 SERIES SPECIFICATIONS

Media—air, hydraulic oils, inert gases
Orifice Diameter—$\frac{3}{64}$", $\frac{1}{16}$", $\frac{3}{32}$", $\frac{1}{8}$"
Pipe Size—$\frac{1}{4}$" NPTF
Maximum Operating Pressure Differential—0 to 150 PSI (up to 225 PSI also available)
Temperature Range—minus 40°F. to plus 180°F.
C_v Factor—$\frac{3}{64}$" .052, $\frac{1}{16}$" .095, $\frac{3}{32}$" .156, $\frac{1}{8}$" .214
Mounting—$\frac{1}{4}$" through-bolt holes.

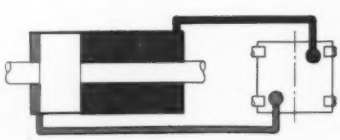
Normally closed—normally closed V933 valves with a neutral position. Generally applied on double-acting cylinders where the piston is in a neutral position without pressure when both coils are de-energized. This permits manual shifting of the piston without operating the valve.



Normally open—normally open V955 valves with a neutral position. Generally applied on double-acting cylinders where both sides of the piston are to be open to pressure when both coils are de-energized. Under certain conditions, the first operating stroke of double-acting cylinders will be smoother with this valve in use.



Normally closed—normally open V935 valves with no neutral position. Generally applied on double-acting cylinders where the piston is to be in retracted or extended position with pressure when both coils are de-energized. Wiring is simple—both coils are operated simultaneously and can be controlled by one single-pole, single-throw switch.



When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed nationally.

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THE CREST OF QUALITY

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION,
THE SKINNER CHUCK COMPANY • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

Things happen fast to a rocketing missile. High-nickel Mumetal shields help tape recorders get it all down accurately.

How Nickel helps record messages from space

When a missile rockets off into space, it detects all sorts of data – temperature, radiation, meteoric dust – the many things we need to know in order to conquer space.

Since radio transmission and reception between missile and ground is not always reliable, some missiles carry an airborne secretary–a multichanneled tape recorder.

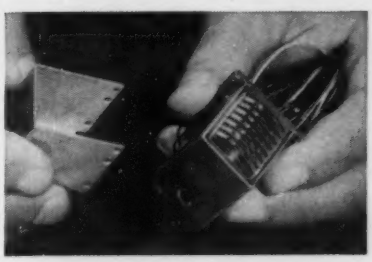
It records as many as thirty different bands of data side by side on a 1½-inch magnetic tape.

Confusion of all the magnetic fields crammed inside the tiny head could cause messages to come out garbled.

But there is a way to keep them straightened out–by using Mumetal* (77% Nickel). This alloy has the unusual ability of soaking up magnetic fields like a sponge. Thin, flat shields of Mumetal siphon off troublesome interference.

The manufacturer also covers the whole head with more Mumetal to bar stray magnetic fields on the outside from getting inside. And then a protective Nickel-chrome plating goes on top of that.

All in all, it's quite a job Nickel does. And something to keep in mind the next time you're faced with a problem in your product or process. If it has to do with high or low temperatures . . . magnetism . . . corrosion . . . fatigue or some other factor, write us. We'd be happy to show you how Nickel, or one of its alloys, may be able to help.



Tiny magnetic head of tape recorder has Mumetal shields to trap magnetic interference, help Davies Lab. Division of Minneapolis-Honeywell pack much in little space. Nickel-chrome plating on cover adds durability, corrosion resistance, and attractive appearance.

*Trademark, Allegheny Ludlum Steel Corporation

The International Nickel Company, Inc.

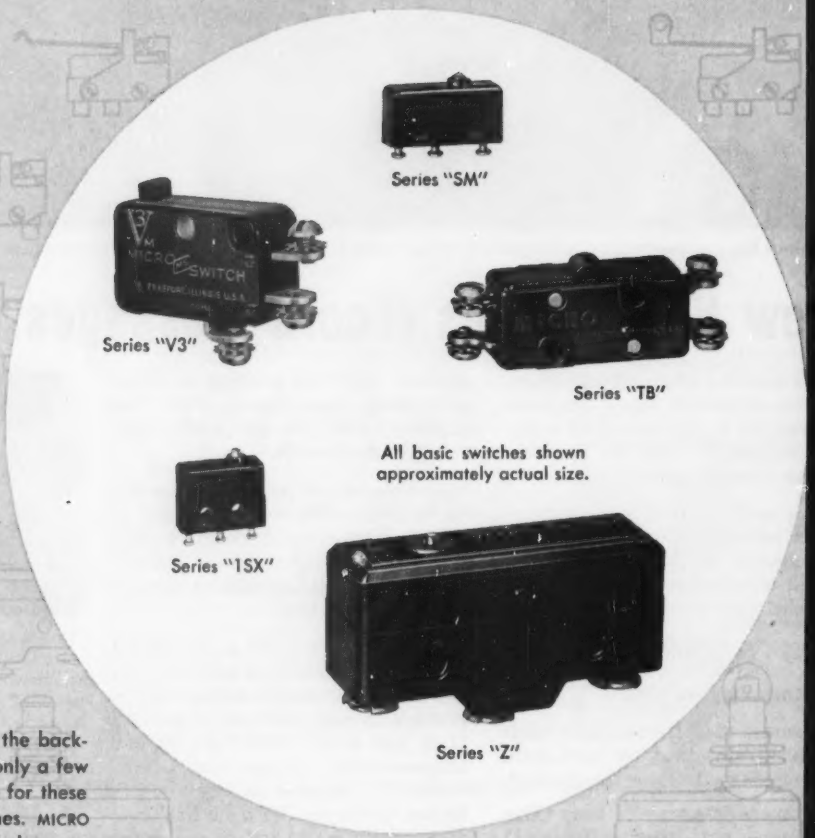
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

←Circle 479 on Page 19

Precision in Small Packages...



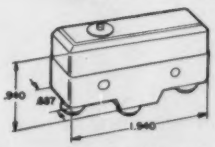
The actuators which form the background on this page are only a few of the hundreds available for these MICRO SWITCH Basic Switches. MICRO SWITCH engineers can help you choose not only the right switch, but also the right actuation method for your particular application.

Start with the Best in Basic Switches!

When design dimensions get you thinking small, don't let that carry over into the consideration of switch quality. MICRO SWITCH Basic Switches consistently save you space, but never at a sacrifice in precision and reliability. Start with the best and be sure of the exclusive MICRO SWITCH spring and anchor designs; get the protection of materials testing "by the inch" and operational tests that exactly duplicate the conditions under which your switch must operate. You also get more years of experience for design consultation because MICRO SWITCH pioneered the subminiature switch industry. Variations on these basic switches number in the thousands, including those designed to meet military standards. You'll find it easy to select exactly the right answer with the prompt help of the nearby MICRO SWITCH branch office listed in the Yellow Pages.

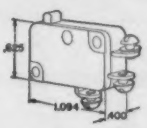
This 72-foot control panel is part of equipment for monitoring tests where your operating methods and environmental conditions can be duplicated exactly for millions of switch operations.

TYPE "Z" AND "A" BASIC SWITCHES



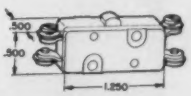
These are the original basic switches that were the pioneers in small snap-action precision switches. Today hundreds of variations serve with precision and reliability in thousands of jobs throughout industry.

TYPE "V3" BASIC SWITCHES



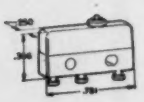
Miniature size with very high electrical capacity. The "V3" Series includes many different types of terminals, contact arrangements, and materials for a wide range of operating temperatures.

TYPE "TB" BASIC SWITCHES



These are small, two-circuit double-break switches for controlling two isolated circuits. They save space and weight, allow flexibility and simplicity of circuit design.

TYPE "SM" BASIC SWITCHES



"SM" Subminiature Switches bring MICRO SWITCH precision to applications where space and weight limitations are critical. Many different "SM" types are available to meet varying requirements for high-temperature applications and long operating life. Special gold or bifurcated contacts are also available.

TYPE "1SX" BASIC SWITCH

This sub-subminiature is the smallest single-pole double-throw snap-action switch available. Despite its tiny size it combines long operating life with ample electrical capacity. This is a perfect example of MICRO SWITCH precision in space-saving sub-subminiature size.

Write for New Catalogs 62 and 63 on Small Basic Switches.

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A division of Honeywell
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MICRO SWITCH Precision Switches

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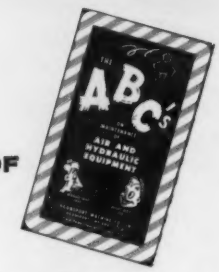
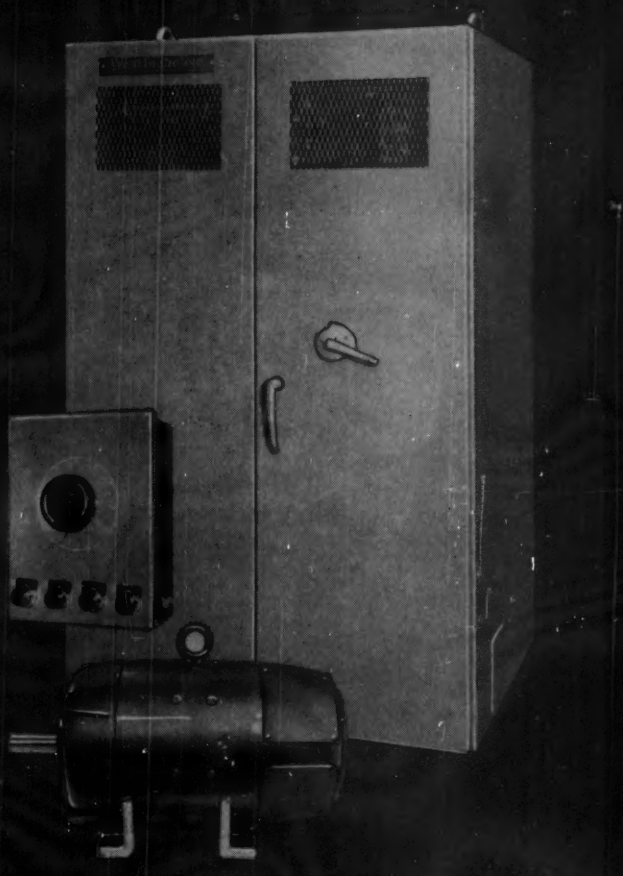


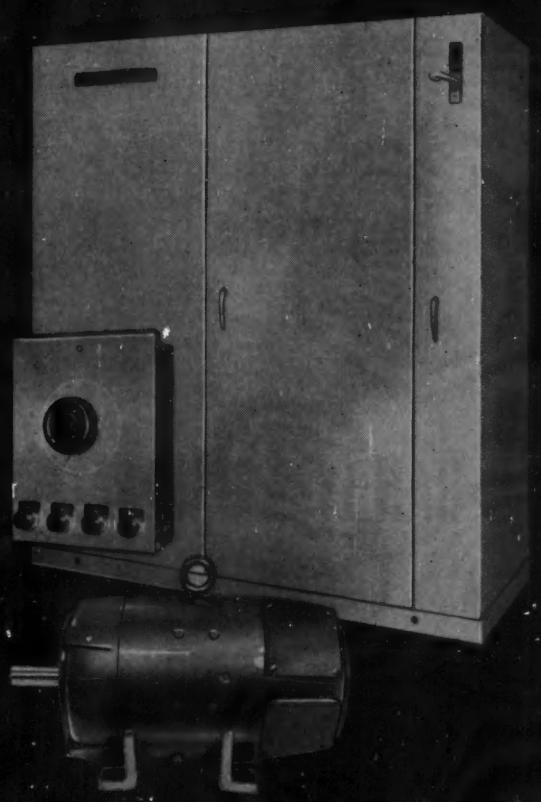
A down-to-earth 20-page booklet on the "rights" and "wrongs" in setting up and servicing air and hydraulic equipment.

MEMBER: National Machine Tool Builders' Assn.; National Fluid Power Assn.

static-powered or motor-generator



Static-Powered model utilizes magnetic amplifier principle to replace conventional motor-generator set. There are no moving parts to weaken from wear. New forced-filtered air ventilation system reduces floor space required . . . simplifies installation.



Motor-Generator model, newly redesigned, features new cabinet, silicone-insulated d-c motor, new electronic regulators which simplify maintenance and positive-pressure ventilation for longer, trouble-free operating life.

WESTINGHOUSE HAS THE ADJUSTABLE-SPEED DRIVE YOU NEED!

When you need smooth, stepless adjustable speed, look to the complete line of new Westinghouse AV adjustable-speed drives . . . available in both static-powered and motor-generator models . . . whichever is best suited for your particular application.

Designed for use with motors 1 to 200 hp, Westinghouse AV adjustable-speed drives provide constant torque over an 8 to 1 speed range—10 to 1 with slight modification—and are also available with constant-hp speed ranges.

All Westinghouse AV adjustable-speed drives are completely pre-engineered, assembled and factory tested. Since all components used are service-proven Westinghouse products, you are assured of the benefits of sole responsibility from one single supplier.

Ask your nearby Westinghouse sales engineer to show you how and where new AV adjustable-speed drives can help you POWER-UP for profit and savings. Or, for complete product information, write Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 19, Pennsylvania. J-22147

YOU CAN BE SURE... IF IT'S Westinghouse

TUNE IN WESTINGHOUSE-CBS TV-RADIO COVERAGE, PRESIDENTIAL CONVENTIONS, JULY 10-29

Circle 484 on Page 19

Titeflex, Inc., Meets Aircraft Fuel, Lubrication and Hydraulic Line Specifications with

HANDY & HARMAN BRAZE 541

Titeflex operator brazes assembly with torch and hand-fed Handy & Harman Alloy BRAZE 541. *Titeflex is unique in that it makes flexible hose assemblies from raw material to end product—"From End to End, Inside and Out, made RIGHT In Our Own Plant."*

This Springfield, Massachusetts, manufacturer of aircraft and missile fuel, lubrication and hydraulic lines finds that silver alloy brazing with Handy & Harman BRAZE 541 meets rigid operating requirements "all the way down the line."

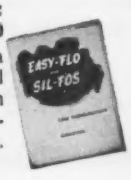
The tubing and fittings of many of the wide range of assemblies made by Titeflex are 321, 316 and 347 stainless steel and Monel. Brazing is a hand torch, wire and HANDY FLUX operation.

BRAZE 541 is a plastic alloy which melts at 1325° F and flows at 1575° F. Its strength—in shear—at elevated temperatures is 21,500 psi at 500° F and 15,000 psi at 750° F. This alloy's ductility in resisting stress and vibration is very high and its resistance to oxidation and corrosion is equally impressive. The composition of BRAZE 541 is 54% silver, 40% copper, 5% zinc and 1% nickel. It meets AMS Specification 4772.

Aircraft and missile component manufacturers and fabricators are finding—to their and their products' benefit—that Handy & Harman silver alloy brazing is the full and *final* solution to their metal-joining problems. BRAZE 541 is but one of a large family of Handy & Harman alloys, for both low and high temperature applications. We would like to more fully acquaint you with BRAZE 541 and with the advantages that come naturally to silver brazing as a metal-joining (both ferrous and nonferrous) method. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.



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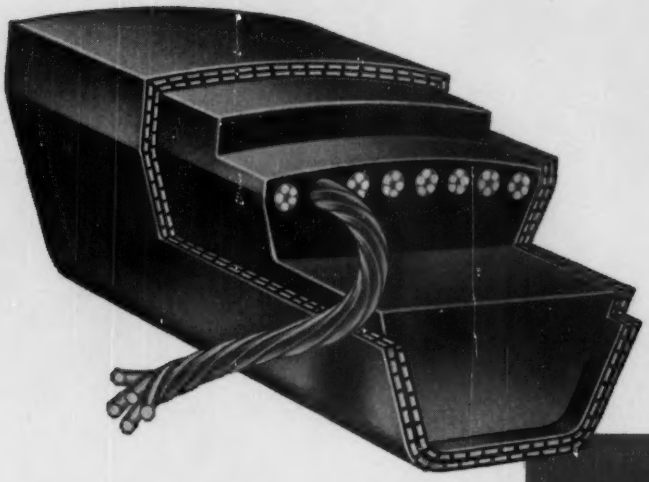
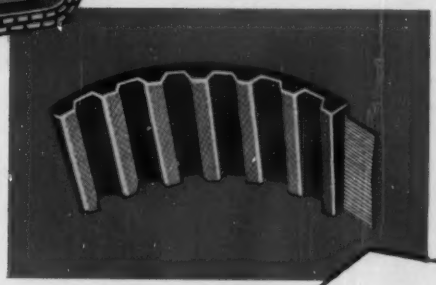


Need High Capacity In Compact Space?

DA 358 V-BELTS. This major design improvement in V-Belts brings you unprecedented compactness, high capacity and drive economy.

Chain and Gear Benefits with No Metal-to-Metal Contact?

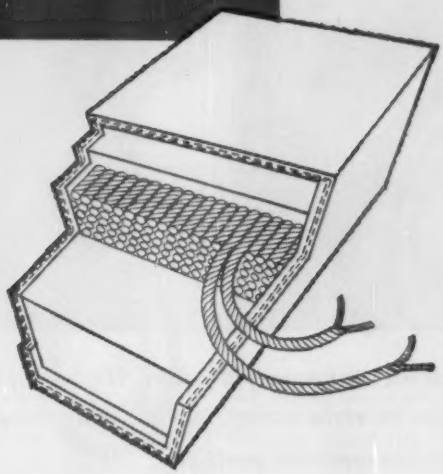
DA POSITIVE DRIVE BELTS. Revolutionary tooth-grip principle; no stretch; no constant lubrication. Highly versatile.



Whatever your V-Belt needs, DURKEE-ATWOOD *meets them*

What do you want in a V-Belt? You want consistent performance, long trouble-free life and full-rated power transmission. That means the belts must be made of the finest quality materials, with careful attention to engineering details, manufacturing processes and testing procedures. Durkee-Atwood V-Belts are made of the newest high tenacity synthetic fibres to assure length stability in storage. The exclusive Durkee-Atwood "Iso-Dynamic" Vertical Matching Machine eliminates the "sag error" that develops when V-Belts are matched on horizontal equipment. This assures equal power transmission from all belts on multiple drives . . . Look to Durkee-Atwood for *quality, service* and *savings ...the most complete line of industrial V-Belts.*

Look for the DA DURKEE ATWOOD *On Your V-Belts*



40% Extra Capacity in Regular V-Belts?

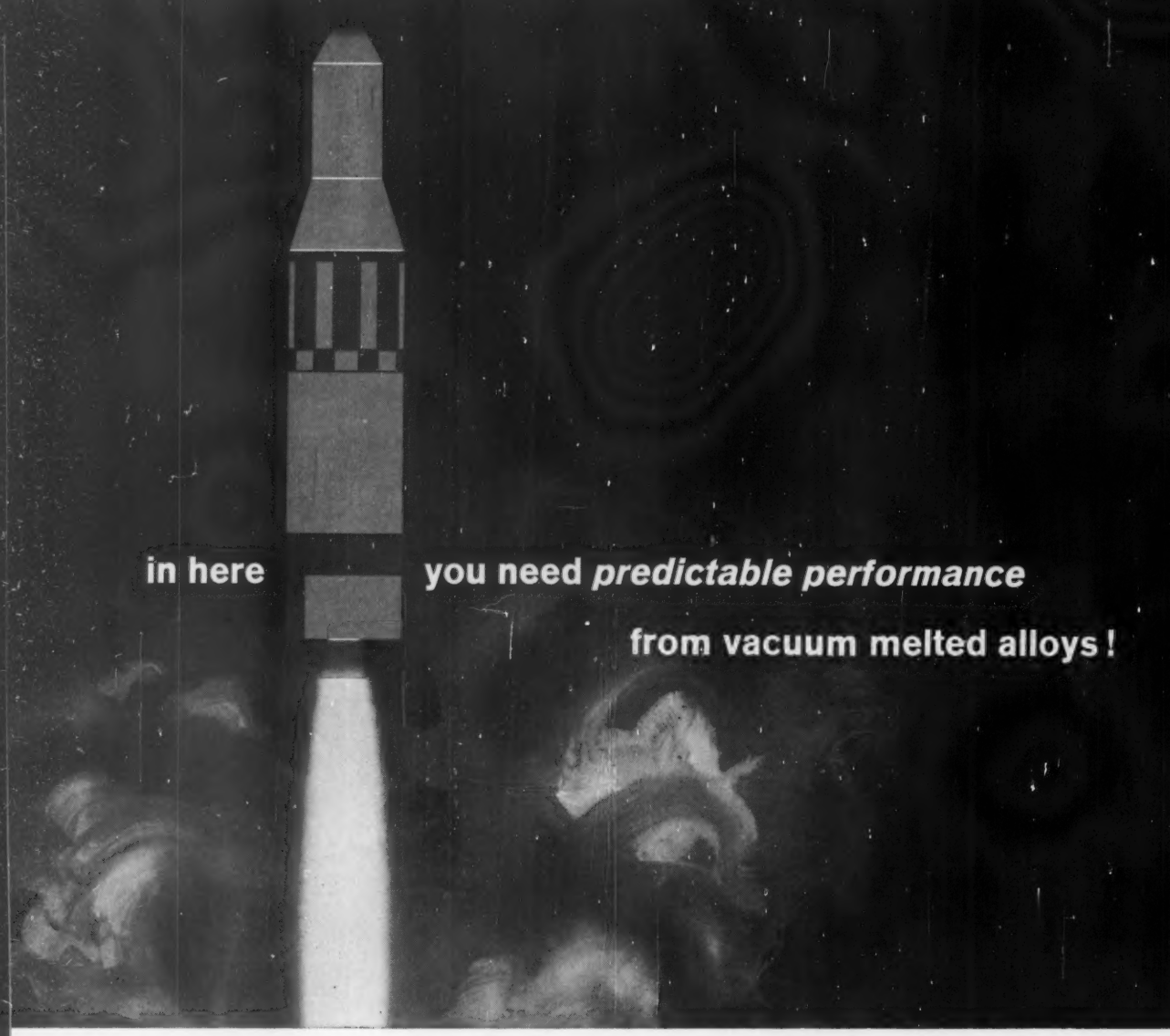
RED SHIELD MULTIPLE V-BELTS. Increased capacity at no increased cost. Available in oil and heat resistant and static dissipating constructions.

Top Performance in Variable Speed Drives?

VARIABLE SPEED BELTS. For constant performance. Abrasion-resistant cover; crowned cross section maintains stability under extreme loads.

DURKEE-ATWOOD V-BELTS

DURKEE-ATWOOD COMPANY MINNEAPOLIS 13, MINNESOTA



Guesswork has no place here. High temperature alloys that make up this missile's critical components must be right every time . . . with predictable performance built into each forging, fastener, and other component parts.

Vacuum melted alloys—new, predictable performing alloys made by Carpenter's exclusive VACUMELTROL and CONSUMET* processes—provide this dependability. And with it, component manufacturers report improved forgeability, better finishes, fewer rejections, faster production.*

Carpenter's many years' experience in producing these cleaner, more uniform and dependable vacuum melted alloys is your assurance of the best predictable performance at elevated temperatures . . . or at any temperature.

A call to your Carpenter representative will put this experience to work for you today. The Carpenter Steel Company, Reading, Pa.

**Carpenter trademarks for alloys melted in vacuum induction and consumable electrode furnaces, respectively.*

Steel

Carpenter steel

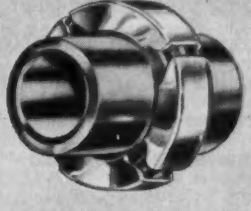
The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 487 on Page 19

UNIVERSAL ELECTRIC FRACTIONAL HP MOTORS

with improved flux control and new *free-aligning* bearing

Rugged, precision built with quality materials, UNIVERSAL ELECTRIC Fractional HP Motors with TORK-SLOT and new *free-aligning* Universal Bearing are ideal for an unlimited number of applications that require maximum dependability with a minimum of maintenance. Shown here are the re-designed Type 118 in sizes from 1/200 to 1/30 HP and the new Type 23 in sizes from 1/50 to 1/12 HP. Write today for complete information.



UNIVERSAL "FREE ALIGNING" BEARING

UNIVERSAL ELECTRIC motors also feature the new *free-aligning* Universal Bearing that eliminates fractional HP motor bearing problems due to misalignment. The new bearing, which has its axis of support in the center rather than at the end, is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. The bearing provides an easier starting motor that runs without a whisper of sound.

UNIVERSAL TORK-SLOT FLUX CONTROL

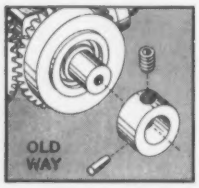
The operating efficiency and starting torque of UNIVERSAL ELECTRIC four-pole, shaded-pole fractional HP motors have been greatly improved by a patented reluctance slot. Called TORK-SLOT, this slot allows improved control over flux distribution and provides an *isolated* torque phase with a uniform air gap between yoke and rotor. Motors that incorporate the TORK-SLOT start easier and operate more efficiently over a wider range than motors with other types of reluctance slots.

UNIVERSAL ELECTRIC COMPANY

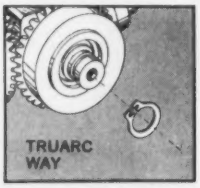
PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 10

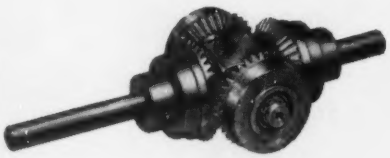
This change of fastening method from



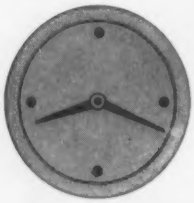
to



improves design of this precision differential



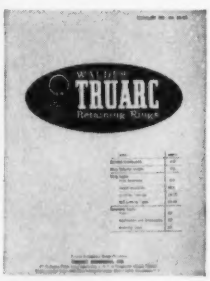
and cuts



assembly time by 97%.

Result: THE DYNAMIC GEAR COMPANY saves $3,930 per 1000 units.

A DESIGN PROPOSITION: Like to see the impact of Truarc Retaining Rings on your product? They can solve many fastening problems by their very simplicity (as demonstrated above). They also save on materials, assembly time and labor—and have effectively reduced the final installed cost on hundreds of products. Our Catalog RR 10-58 shows how other designers use Truarc Rings on more than 70 different products. For immediate action, call your nearest **Authorized Truarc Distributor.**
He's as close as your Classified Telephone Directory.
Look under: "Rings, Retaining."



WALDES
TRUARC® RETAINING RINGS

WALDES KOHINOOR, INC., 47-16 Austel Place, Long Island City 1, N. Y.

9 OUT OF 10 PRODUCTS CAN BE IMPROVED WITH TRUARC RETAINING RINGS

© 1960 WALDES KOHINOOR, INC.

WEAR RESISTANT

THOMSON

60 Case

AVOID the HIGH COST and difficulty of fabricating long, hard & straight parts by conventional methods!

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

ELIMINATE WEAR and REDUCE COST

60 Case is the result of over 15 years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining. *Write for literature and name of your local representative.*

For emergency needs call collect
MAnhasset 7-1800

ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- NICK-& DENT-PROOF
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

GUIDE RODS • SHAFTING • ROLLS • TRAVERSE RAILS
PISTON RODS • ARBORS • LEADER PINS • TIE RODS
KING PINS • AXLES • CONTROL RODS • GUIDE POSTS
MANDRELS • BEARING ROLLERS • SPINDLES

THOMSON INDUSTRIES Inc.

Dept. C-5, Manhasset, New York

Circle 490 on Page 19

PARTS HARDENED to 60 C...
increase life...reduce cost!

Reduce power requirements and operating costs here...

JEFFREY

RIVETLESS CHAIN

for general conveying systems, overhead trolleys, scrapers

CHAIN STRENGTH is achieved from heat-treating quality steel; addition of bulk weight only increases power requirements. Jeffrey drop forged, heat-treated Rivetless Chain ranges to a maximum ultimate strength of 130,000 lbs. The weight —9 lbs. per foot.

Within very broad limits, Jeffrey Rivetless Chain will operate over irregular courses in either vertical or horizontal directions.

Links and pins can be reversed when excessive wear is evident, thereby increasing chain life while greatly decreasing maintenance costs. Simplicity of design makes single link or section replacements fast and easy.

Jeffrey Rivetless Chain is detachable. Assembly is aided by the cutout portion of center link which allows the side bars to be brought together for ease of insertion or removal of the pin.

Whether replacing links or specifying a complete conveyor system, the Jeffrey district office or distributor in your area can make the job initially less expensive—ultimately more profitable.

Write for Catalog #899. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

Jeffrey Scraper Conveyor with two strands of rivetless chain

Available in alloy heat-treated steel

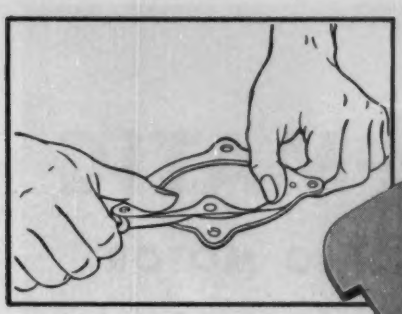
STRONG...
without needless bulk weight

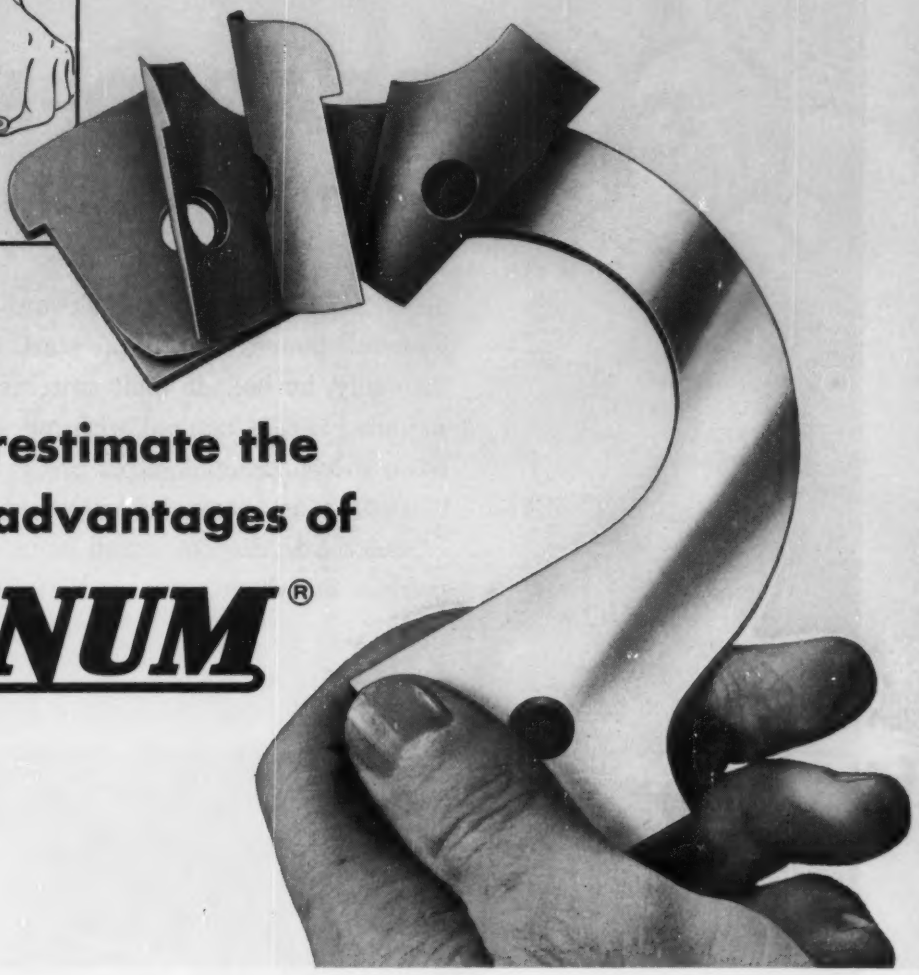
DETACHABLE...
for fast, easy assembly—lower maintenance costs

ADAPTABLE...
to irregular courses, vertical or horizontal conveyors

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING





Never underestimate the cost-saving advantages of

LAMINUM®

We address this statement to design, tool, production, inspection and assembly engineers . . .

Holding to extremely close tolerances is a costly procedure. You know that. What you may not know is that frequently you can ease up on tolerances without sacrificing a single thousandth of your precise assembly objectives.

How? By using LAMINUM!

LAMINUM is the registered trade name for laminated shims whose layers are completely surface-bonded to look and act like solid metal. The layers are easily p-e-e-l-e-d to bring the shims to any desired thickness—for a thousandth fit right at assembly.

With LAMINUM in the specs, machining operations become less critical, faster and less costly. Inspection is simpler and less costly. The savings carry over to the assembly line, too. No stand-by equipment. No machining. No grinding. No counting, stacking or miking. And no dirt between layers—ever!

Get the facts about cost-saving LAMINUM, and the custom-stamping service that goes with it. They're all illustrated and described in our Shim Design Folder No. 3. Write for it.

THE LAMINATED SHIM COMPANY, INC.

West Coast Sales and Service
600 SIXTEENTH ST., OAKLAND, CALIF.

Home Office and Plant
1206 UNION STREET, GLENBROOK, CONN.

Circle 492 on Page 19

BRASS • MILD STEEL • STAINLESS • ALUMINUM • WITH LAMINATIONS .002" OR .003"

FRANKLIN ELECTRIC

FOR

GARAGE DOORS
VENTILATORS
INDEX TABLES
MACHINERY
CONVEYORS
TRACK DOORS
MONORAILS
LOUVERS
X-RAY UNITS
POSITIONERS
YARD GATES
CURTAINS
REMOTE VALVES
DUMB WAITERS

GEAR-O-MATIC

INSTANT-REVERSING MOTOR

DEPENDABILITY for stop-go, forward-reverse motion with full power, high-torque start. Operable manually, by built-in limit switches, or as automation requires. **SAFETY** assured with automatic, instant reversal when driven product meets predetermined resistance. **ECONOMY** as a low cost packaged operator unit ... quick and easy to install or integrate with your product or system.

POWER-FULL GEAR REDUCTION

Worm gear drive from capacitor-start Franklin Electric Motor applies full power instantly upon reversing at built-in limit switch setting.

Driven system or product may be instantly reversed at any time during forward or reverse cycle by manual or automatic switch; or by automatic operation of built-in safety device.

GEAR-O-MATIC® performs all functions typically required in radio-controlled or manual-switch garage door operation ... functions applicable to operation of many other products ... perhaps yours.

PATENTS PENDING

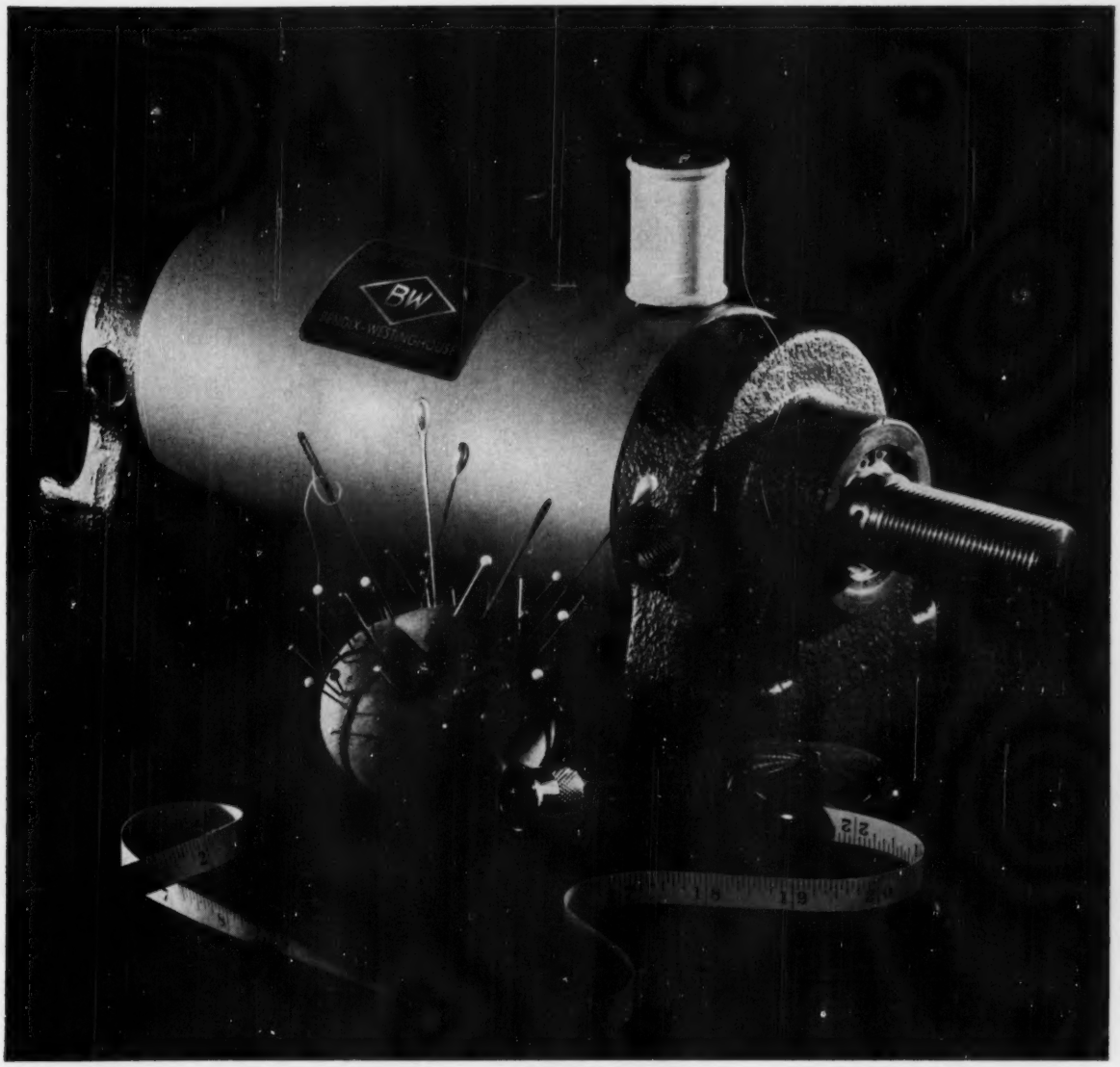
Integrated with the Franklin Electric Motor is a control box with 24 volt A. C. circuitry. System includes plug-in connection for radio or automation control and receptacle for light bulb or power extension line. All limit and safety reversing switch settings are adjustable.

From the Home of DEPENDABLE Electric Motors

For more data write for "FACTS ABOUT FRANKLIN GEAR-O-MATIC®"

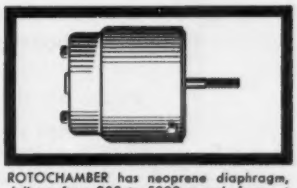
Franklin Electric Co., Inc.
BLUFFTON, INDIANA

Circle 493 on Page 19

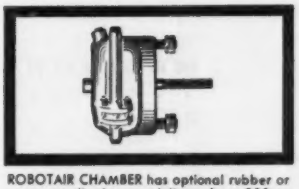


Tailored to fit your needs... Bendix-Westinghouse Power Cylinders

You get made-to-your-measure, top-performing fluid power controls when you specify Bendix-Westinghouse Power Cylinders. Whatever your job requirements, our design and application experience in every field of industry enables us to deliver power cylinders exactly tailored to your needs. Bendix-Westinghouse piston-type cylinders operate up to 200 psi air and 1800 psi oil. Furthermore, our comprehensive inventory of machined parts and our manufacturing flexibility enable us to provide fast delivery of standard units as well as many specialized sizes and mounts. Write today for complete information on the quality advantages you enjoy with power cylinders designed and manufactured by Bendix-Westinghouse.



ROTOCHAMBER has neoprene diaphragm, delivers from 900 to 5000 pounds force at 100 psi air pressure.



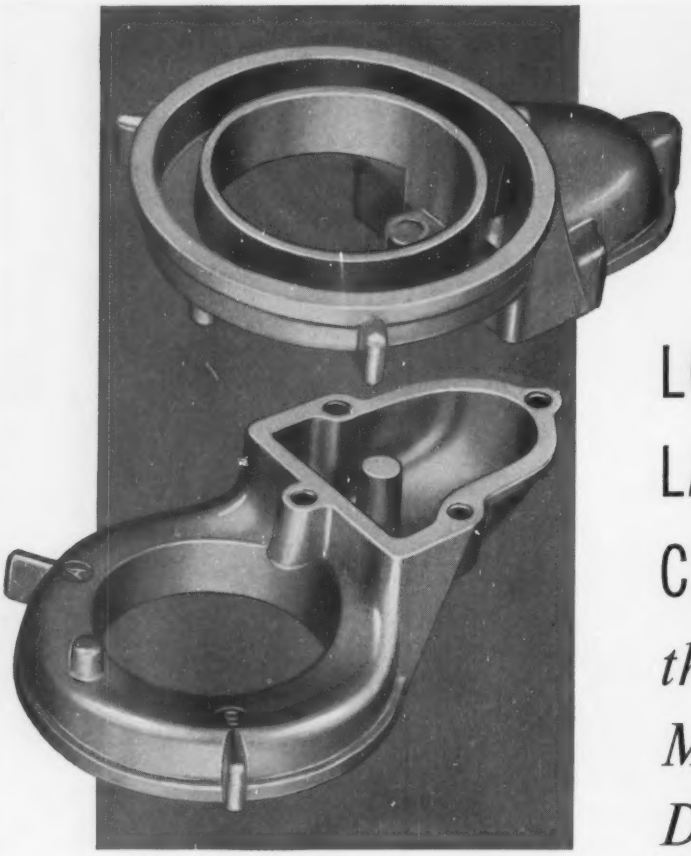
ROBOTAIR CHAMBER has optional rubber or neoprene diaphragm, delivers from 300 to 3600 pounds force at 100 psi air pressure.

Bendix-Westinghouse BW

INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

Circle 494 on Page 19



LOW LABOR CONTENT *the Master Design Guide*

The offset planes, the channels, holes, and functional shapes are all cast to size in the Harper-Wyman gas range top burner part here illustrated.

It is a good example of high utilization of the die casting process for mass production parts.

The Master Design Guide for the seasoned and skilled mechanics at Madison-Kipp, in cooperation with customer designers, is high level quality, from high level tooling for low secondary labor content.

Please clip this ad as a reminder to contact us when you have die casting requirements.

with MADISON-KIPP zinc and aluminum die castings

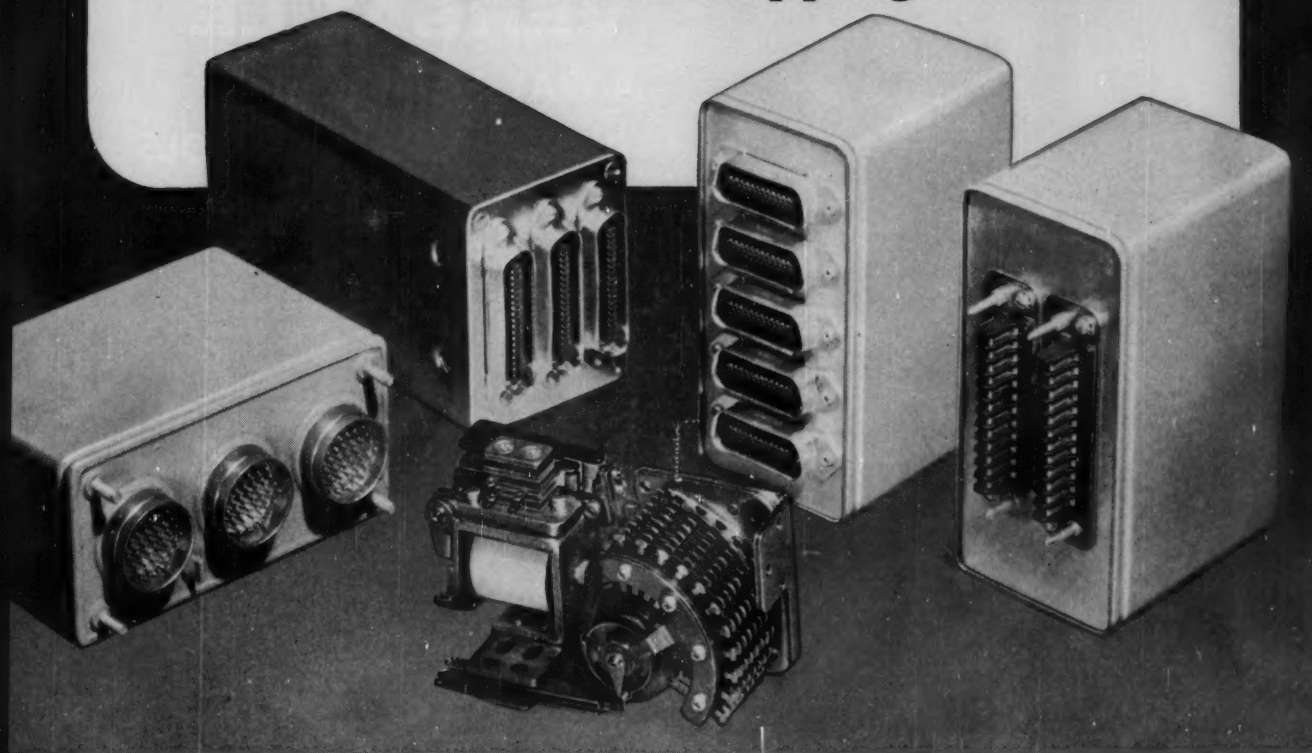
kipp

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubricating Engineering • Originators of Really High Speed Air Tools

NOW... from CLARE...

a new 10-Point Stepping Switch



for long life digital operation

Small, lightweight and capable of a minimum of over 100,000,000 operations,* the new CLARE Type 210 Stepping Switch is specially designed for digital operation. It is ideally suited as a component for sequence control, totalizing, sampling or single point selection. It transfers from Position 10 to Position 1 without special circuitry.

This new switch has all the improved features which have made the Type 211 an ideal component for complex switching requirements—long life, excellent capacity and freedom from maintenance. A wide variety of hermetically sealed and dust cover enclosures are available with terminals or connectors to suit the application.

Send for Bulletin CPC-6 for complete information. Address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois; In Canada: C. P. Clare Canada Ltd., P. O. Box 134, Downsview, Ontario. Cable Address: CLARELAY.

*with twelve 10-point levels . . . 300,000,000 operations with four 30-point levels (properly lubricated and adjusted).

ELECTRICAL DATA

OPERATING SPEEDS—Self-interrupt speed: 60 sps at 25°C on nominal voltage. Remote impulse speed: 30 sps at 25°C on nominal voltage with 66% make impulse.

OPERATE & RELEASE TIME—Operate time: 20 ms at 25°C on nominal voltage. Release time: 10 ms at 25°C on nominal voltage.

OPERATE & RELEASE VOLTAGE—Maximum pull-in at 25°C is 75% of nominal voltage. Minimum dropout at 25°C is 3% of nominal voltage.

BREAKDOWN TEST—1000v, rms, 60 cps, is standard.

COILS—Coil resistances for typical voltages are shown below:

VOLTAGE Vdc	1-8 LEVELS OHMS	9-12 LEVELS OHMS
6	1.5	1.5
12	6	6
24	24	20
48	100	70
60	150	100
110	600	400

MECHANICAL DATA

OVERALL DIMENSIONS—Length (maximum)—4-5/16 in. Height (1C interrupter, 1C O.N.S.)—2¾ in. Width—from 1-5/16 in. for 3 levels to 2-13/16 in. for 12 levels.

NET WEIGHT—From one pound for 3 levels to 1 ½ pounds for 12 levels.

BANK CONTACT—Standard is phosphor bronze. Also available are coin silver or gold plated phosphor bronze.

MAXIMUM BANK LEVELS & PILEUPS

Type of operation (points)	10	30
Bank levels maximum (electrical)	12	4
Interrupter springs	6	6
Off-normal springs	6	6
Number of ratchet teeth	30	30

WIPERS—Standard wipers are non-bridging phosphor bronze with coin silver and gold-plated phosphor bronze available in either non-bridging or bridging models.

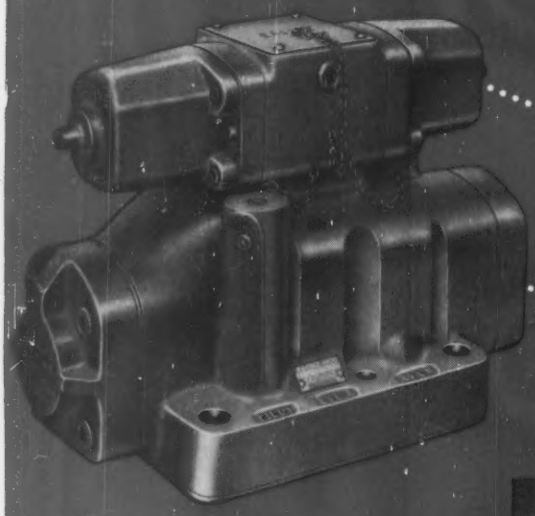
CLARE

Relays and Related Control Components

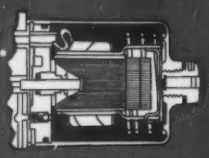
Circle 496 on Page 19

RACINE-SECO

VERSATILE 4-WAY HYDRAULIC DIRECTIONAL CONTROLS

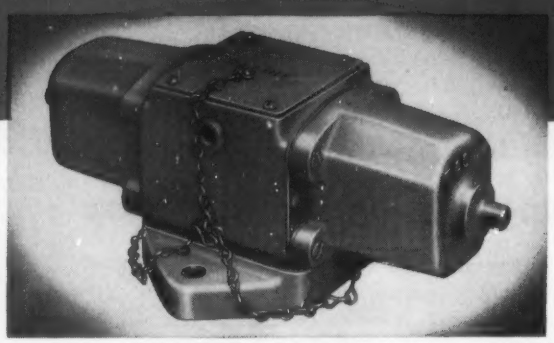


NEW 1¼" VALVE ILLUSTRATED



OIL IMMERSED SOLENOIDS — Solenoids are available with oil filled cavity for better heat transfer, lubrication and cushioning of moving parts, thus contributing to longer valve life.

THROTTLING END CAPS — End caps are available with pilot choke adjustments for controlling speed of valve spool independently in all directions of movement. This includes independent control of all spring return and spring centering actions, with time delay up to 5 seconds.



FEATURES

- Design conforms to J.I.C. standards
- High flow capacity
- Direct or remote pilot pressure operation
- Throttling end caps for ¾" and 1¼" sizes
- Oil immersed solenoids available
- Sub-plate mountings on all sizes

From a design and operational consideration these RACINE-SECO valves are the finest directional controls made. Compact streamlined design — dust proof construction. RACINE-SECO 4-way valves are available in single solenoid spring return and double solenoid standard action or spring centering.

Sizes ¼", ¾" and 1¼" up to 2000 psi.

Write for RACINE-SECO Catalog No. 59-A describing our complete line of Hydraulic Equipment.

RACINE HYDRAULICS & MACHINERY, INC.
RACINE, WISCONSIN

One Source — One Responsibility for all your hydraulic needs.

Circle 497 on Page 19

Circle 498 on Page 19→

QUALITY CONTROL

That's the secret of good breeding . . . and why Federal Ball Bearings are all champions.

Take race grinding: the operator must gage race diameter, roundness, contour, centerline, eccentricity of raceway with O.D., parallelism of the race with the face of the bearing ring . . . and finish. Then line inspectors double check.

This is typical of the quality control all along the Federal production line. Double work? Sure! But it means a bearing as close to perfection as a bearing can get. One that's twice as reliable, too. That's why they're specified by so many top industrial companies. Why not put them to work yourself? Start today by sending for the Federal catalog where you'll meet hundreds of different type ball bearings . . . all top breed . . . in 12,000 sizes!

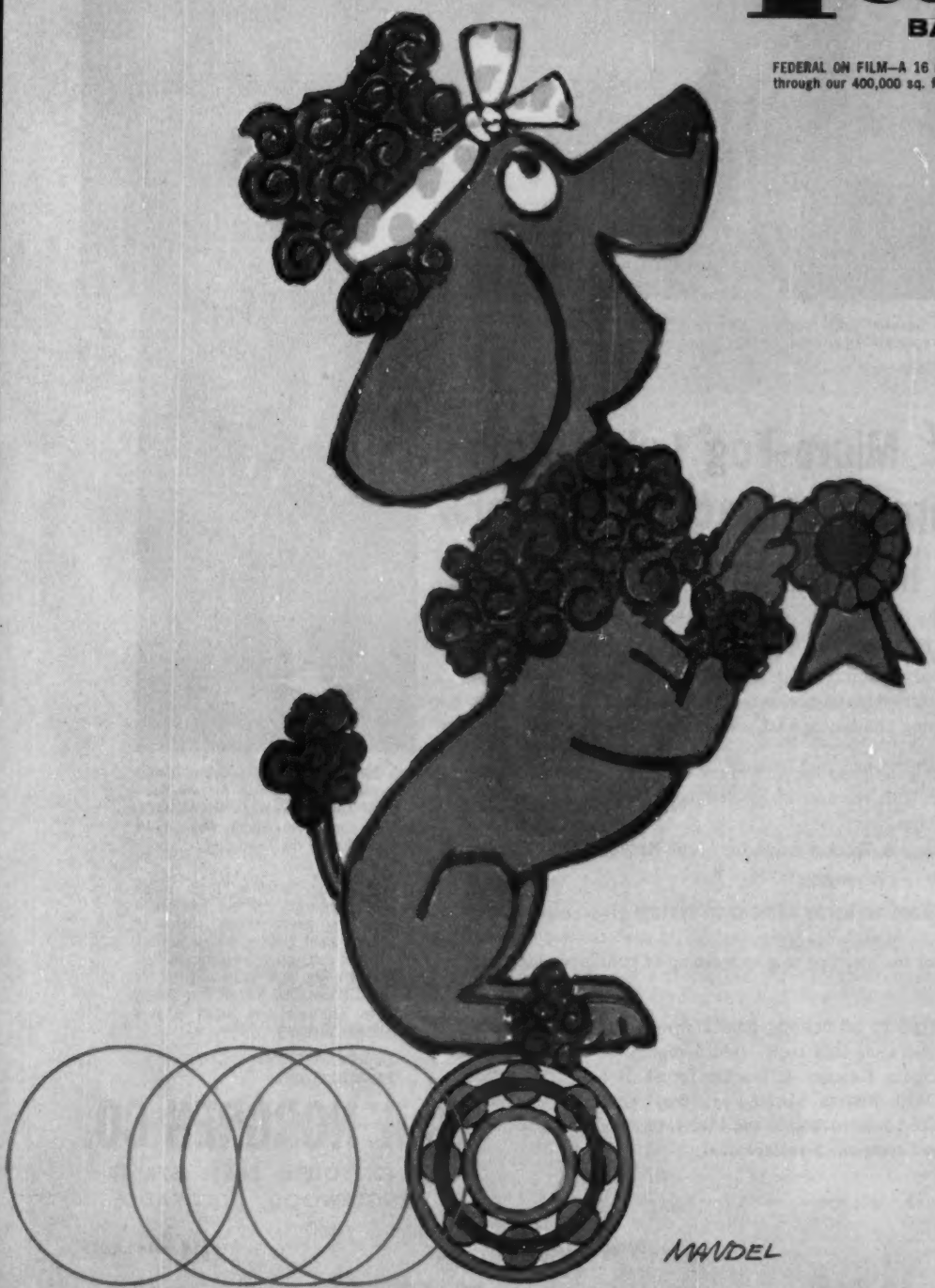
The Federal Bearings Co., Inc., Poughkeepsie, N. Y.

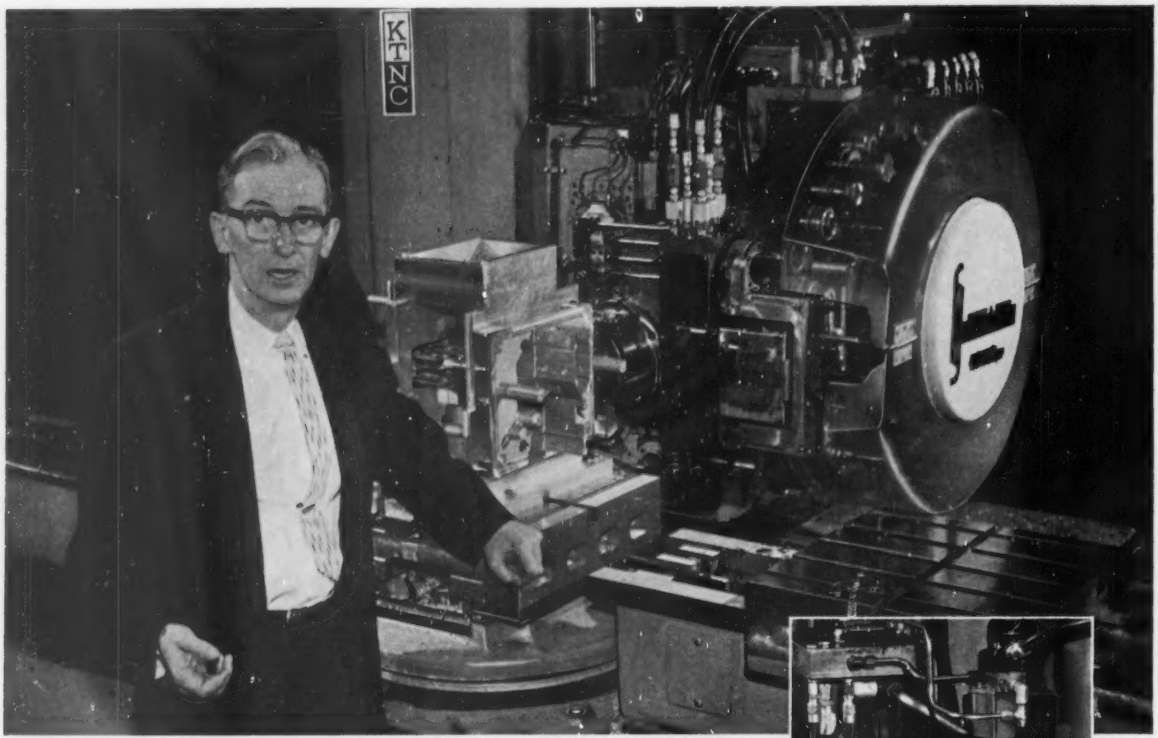
One of America's largest ball bearing manufacturers

Federal

BALL BEARINGS

FEDERAL ON FILM—A 16 mm. color sound film takes you through our 400,000 sq. ft. plant. Loaned free. Just ask for it.





Mr. Julian Kerlin, Field Service Engineer for Kearney-Trecker Service Division, explains the contribution of Micro-Fog Lubrication to MILWAUKEE-MATIC reliability and ease of servicing.

Norgren Micro-Fog® Lubrication gives Kearney & Trecker greater flexibility in machine design

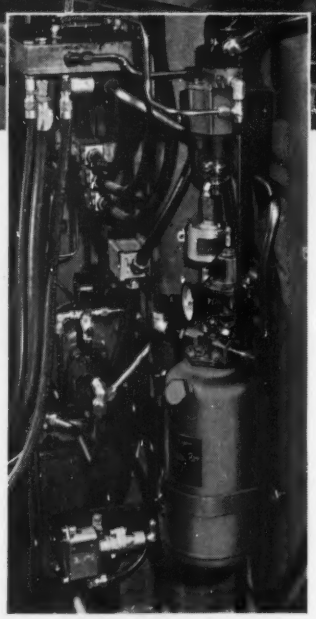
The new Kearney & Trecker tape-controlled MILWAUKEE-MATIC is an outstanding example of flexibility in modern machine design. In a single machine, the MILWAUKEE-MATIC performs all the operations of milling, drilling, reaming, tapping and boring that usually require several machines.

The Milwaukee-Matic is designed for maximum "chip time" and minimum set up and down time. This requires high reliability of operation and provision for rapid servicing.

This is why Kearney & Trecker engineers chose **Norgren** Micro-Fog for the lubrication system.

The Micro-Fog centralized air-borne lubrication system gives constant, reliable, metered lubrication at each bearing point. Alarm devices are connected to the control system of the machine to give warning of conditions affecting proper lubrication.

Micro-Fog is conducted to all bearing points through tubing, eliminating the need for cumbersome and costly return piping, oil filters, sumps and pumps. The result, as Kearney & Trecker found, is a wider latitude in machine design. With **Norgren** Micro-Fog, they were able to make maximum use of unitized construction in the MILWAUKEE-MATIC, providing for fast disassembly and component replacement.



This Norgren Micro-fog Lubro-Control Unit provides lubrication for the bearings on Kearney-Trecker's MILWAUKEE-MATIC, and for the slides, ways, gears and clutches in the head.

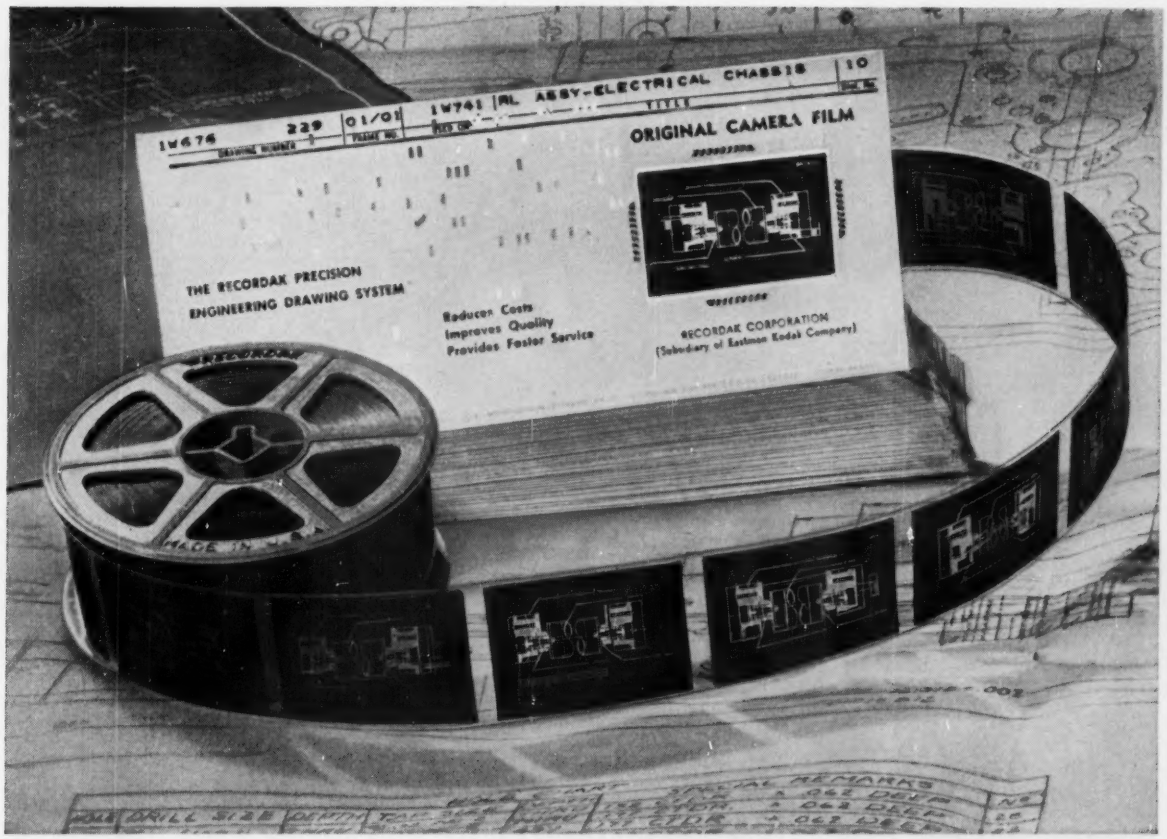
If you design machine tools which require measured, reliable lubrication of bearings, gears, slides, chains or ways, and want greater design flexibility, it will pay you to investigate Norgren Micro-Fog Lubrication. Write for detailed information, or call your nearby Norgren Representative listed in your telephone directory.

FOUNDED IN 1926

C.A. NORGREN CO.

3442 SOUTH ELATI STREET
ENGLEWOOD, COLORADO

Circle 499 on Page 19



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Complete active drawing files are at the fingertips in just 5% of the space needed for originals. Any drawing—out of thousands—found quickly and viewed clearly in a RECORDAK Film Reader.

This, naturally, reduces the need for reference blueprints, adds up to notable savings in time and printmaking costs. You can also count on savings when you need prints. For with this new system, reduced-scale paper prints can be made directly from your aperture cards by low-cost photographic, xerographic or electrostatic methods. Also, duplicate film cards for branches, vendors, or government agencies can be made for pennies apiece.

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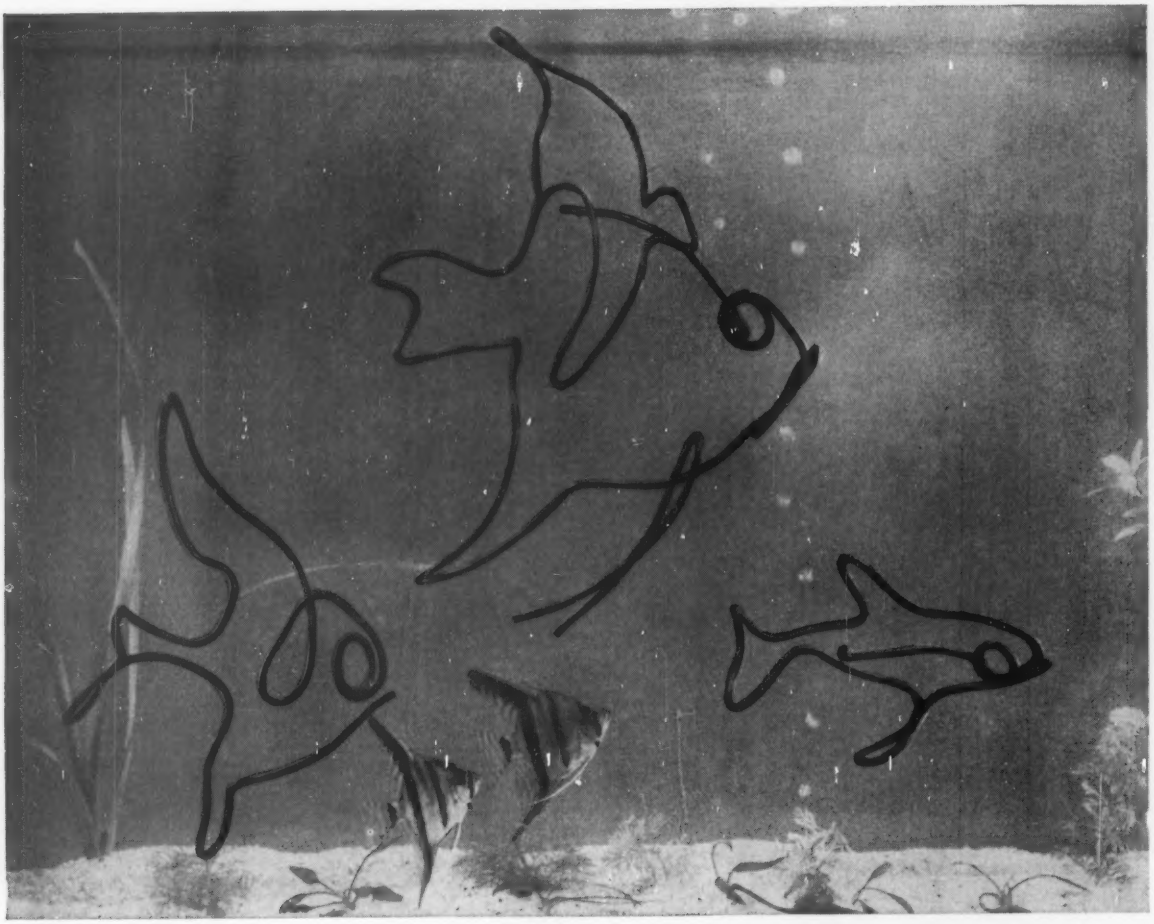


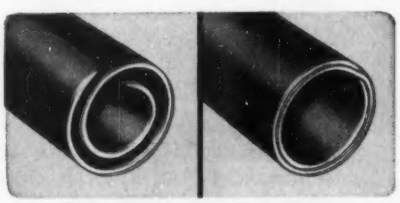
Bundy can mass-fabricate practically anything

. . . and we use Bundyweld®—the double-walled steel tubing—for parts that must meet rigid specifications

YOUR tubing headaches are Bundy's business. Our tubing engineers will work with you at any stage in the development of your product. With years of problem solving experience, we can often suggest short cuts that cut costs of tubing parts—or find practical solutions to tough bends.

Then we'll mass-fabricate these parts on machines specially designed by Bundy for precision bending. We use Bundyweld, the original double-walled steel tubing, that has become the safety standard in small-diameter tubing. It's thinner walled—yet stronger, has high bursting and fatigue strengths. Covered by Government Spec. MIL-T-3520, Type III.

Why don't *you* take advantage of Bundy's complete service: expert engineering help, mass-fabrication savings, *Bundyweld* tubing. For more information see Sweet's Product Design File, 1e/Bu . . . or contact us!



Bundyweld is the only tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ⅝" O.D.

There's no substitute for the original Bundyweld Tubing.

BUNDY® TUBING COMPANY

HOMETOWN, PA. • DETROIT 14, MICH. • WINCHESTER, KY.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

Another new development using

B.F.Goodrich Chemical *raw materials*

Line of Pendent SAFE switches with housing of Hycar are manufactured by Joy Manufacturing Company, Electrical Products Division, St. Louis, and distributed by Graybar. Switches are available in 2- 4- and 6-button models with choice of lettered legends. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.

For extra safe, improved operation

New pendent switch is encased in Hycar rubber

This new pendent switch is designed for use on hoists and other devices where suspended or portable switches are required. It is encased in a housing made from tough, resilient Hycar nitrile rubber.

Because Hycar permits such accurate molding, "O" ring seals are molded right in to make the switch watertight. Like any product made of Hycar, this housing is unusually resistant to oils, greases, acids and other corrosives. Unlike other materials tested, Hycar will not harden or stiffen at low temperatures. Pushbutton diaphragms stay flexible.

Another important advantage to the design of these switches is the resilience provided by the covering which protects the switch from damage even if it hits a hard object.

Here's another example of how Hycar nitrile rubber is improving products and opening new markets. For further information, write Dept. FO-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar

Rubber and Latex

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a division of The B.F.Goodrich Company

B.F.Goodrich GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

OHIO RUBBER

"CUSTOMEERED* COMPONENTS BASIC TO INDUSTRY"

ORCO IDEA PARTS

shape up OEM designs—profitably!

OHIO RUBBER IS THE GOOD SOURCE FOR THE OEM!

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ORCO CUSTOMEERING* is geared to cut production costs—to deliver a better part. And it goes to work for you as soon as performance requirements are checked, a materials recipe is formulated, expense-shaving design modifications, if necessary, suggested. The full scope of ORCO integrated design, research and practical ingenuity in custom-manufacture of rubber, synthetic rubber, silicone rubber, polyurethane, and flexible vinyl components is focused on your component.

ORCO CAPACITY offers the facilities of four modern plants. These include design, building, and maintenance of precision molds and dies . . . permanent bonding-to-metal . . . compression and transfer molding . . . extruding of all shapes, sizes, and types . . . complete laboratory facilities . . . statistical quality control . . . coordinated production control.

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DE-160

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A DIVISION OF THE EAGLE PICHER COMPANY

Webster hydraulics raise production, lower costs

Two ton push-up! Second story operators like this powerful lift truck speed material handling and construction — save time, money. Thanks to hydraulics! Fingertip control raises the load, lowers it — tilts it forward or back. And a Webster Directional Control Valve channels the action. Deftly. Accurately.

Where space is at a premium — this versatile valve fits in. It's the smallest size for rating! Operating pressures range to 2000 psi, shock pressures to 5000 psi . . . with lowest back pressure. Inlet and outlet connections can be made from the same end to simplify hook up. And it's provided with alternate porting positions. Sizes from single spool to 6 spools; capacities from 20 to 40 gpm. Parallel design permits control of up to 6 independent circuits!

Build construction equipment? Machines for industry or agriculture? Keep this Webster Directional Control Valve in mind.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

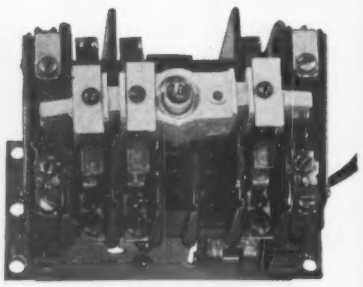
RACINE · WIS

STACK TYPE
DIRECTIONAL CONTROL VALVE
Bulletin HY 1 contains complete engineering data — installation, performance, specifications. Write for it!

Circle 504 on Page 19

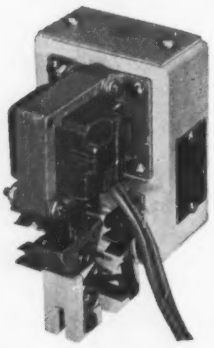
Meet military spec requirements

AC contactors



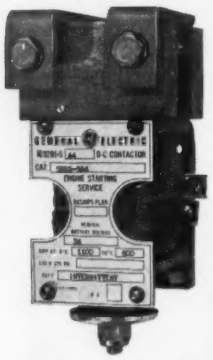
For magnetic operation on motor loads through 200 hp at 440 volts, 3-phase, 60-cycle; are available with 3 or 4½ poles.

AC relays



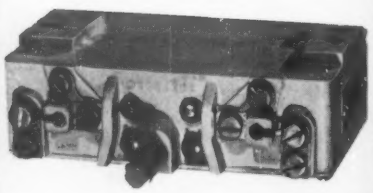
Interlocking or undervoltage relays; available with four to eight poles in ratings to 10 amps; both single-pole (above) and multi-pole contact arrangement.

DC contactors



Diesel-starting (above), time-delay, sizes 1, 2, and 3 for magnetic operation on motor loads through 25 hp at 230 v d-c. Submarine service forms available.

Thermal overload relays



Both heater- (above) and induction-type; adjustable from 90 to 110 percent of rating; resetting time 60 seconds after tripping.

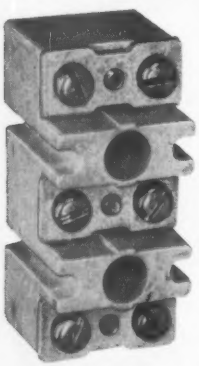
Reset relays

A remote method for resetting overload relays; consist of potted solenoid coil and a mechanical linkage on corrosion-resistant steel base with insulated leads.

Panel-mounted pushbuttons

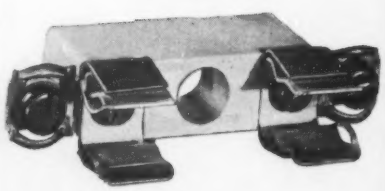
For use on a-c or d-c circuits where momentary contact is required; available in standard or oiltight forms in variety of contact arrangements.

Terminal boards



Designed for 25-, 50-, 100-, and 150-amp circuits. Termination points—either 2, 3, 5, 7, or 9—have fire-resistant base.

Fuse blocks



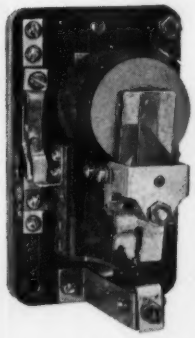
Rated up to 30 amps; blocks consist of a fire-resistant molded-compound base with metal terminals and fuse clips; convenient single-hole mounting.

Resistors

Starting and regulating duty on motor and generator field adjustment, load banks, etc.; available in ratings from 21.5 to 42.5 amps continuous and five lengths.

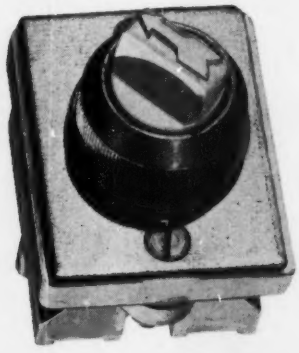
with General Electric HI-shock control components

DC relays



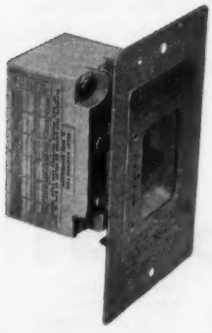
Multi-current and overcurrent relays (above) are used as interlocking or undervoltage relays, and on electronic applications requiring shock-damage design.

Panel-mounted selector switches



For use on either a-c or d-c circuits where maintained contact is required; available in three forms; can be mounted on panels up to 3/16-inch thick.

Manual starters



For single-speed, 1- or 3-phase, squirrel-cage induction motors or d-c motors. Size 0 starters are dripproof or flush-mounted; rated 3 hp 440-volt a-c maximum.

A complete line of devices designed for extreme environmental applications

- Shock
- Vibration
- Humidity
- Tilting
- Fungus
- Temperature

Whether you're designing equipment to meet exacting Navy specifications . . . or for missile hard-site applications where adverse environmental conditions are inherent . . . one or more of General Electric's HI-shock control components may well be the answer to your circuit design problems.

All General Electric HI-shock control components are designed, built, and tested to perform reliably in virtually all operating conditions including shock, humidity, fungus, vibration, tilting, and high or low temperature.

Outstanding features you get with the complete line of General Electric HI-shock control devices include: 1) all front connection for easy servicing; 2) fire-resistant compound bases, and 3) all corrosion-resistant metal parts.

CATALOG OFFERS COMPLETE DESIGN DATA

General Electric's Control Components Catalog contains dimensional outlines, electrical design data, environmental limits, MIL Spec references, and prices on all HI-shock devices. To have this valuable information at your fingertips, call your General Electric Sales Engineer today. Or, mail the coupon below. Industry Control Department, Salem, Virginia.

Progress Is Our Most Important Product

GENERAL ELECTRIC

SEND TODAY FOR FREE CATALOG

General Electric Co., Section A785-15
Schenectady 5, New York

Please send me a copy of the Navy Control Components catalog, GEA-6978, with descriptions, specifications, and pricing data on the complete line.

Name_____

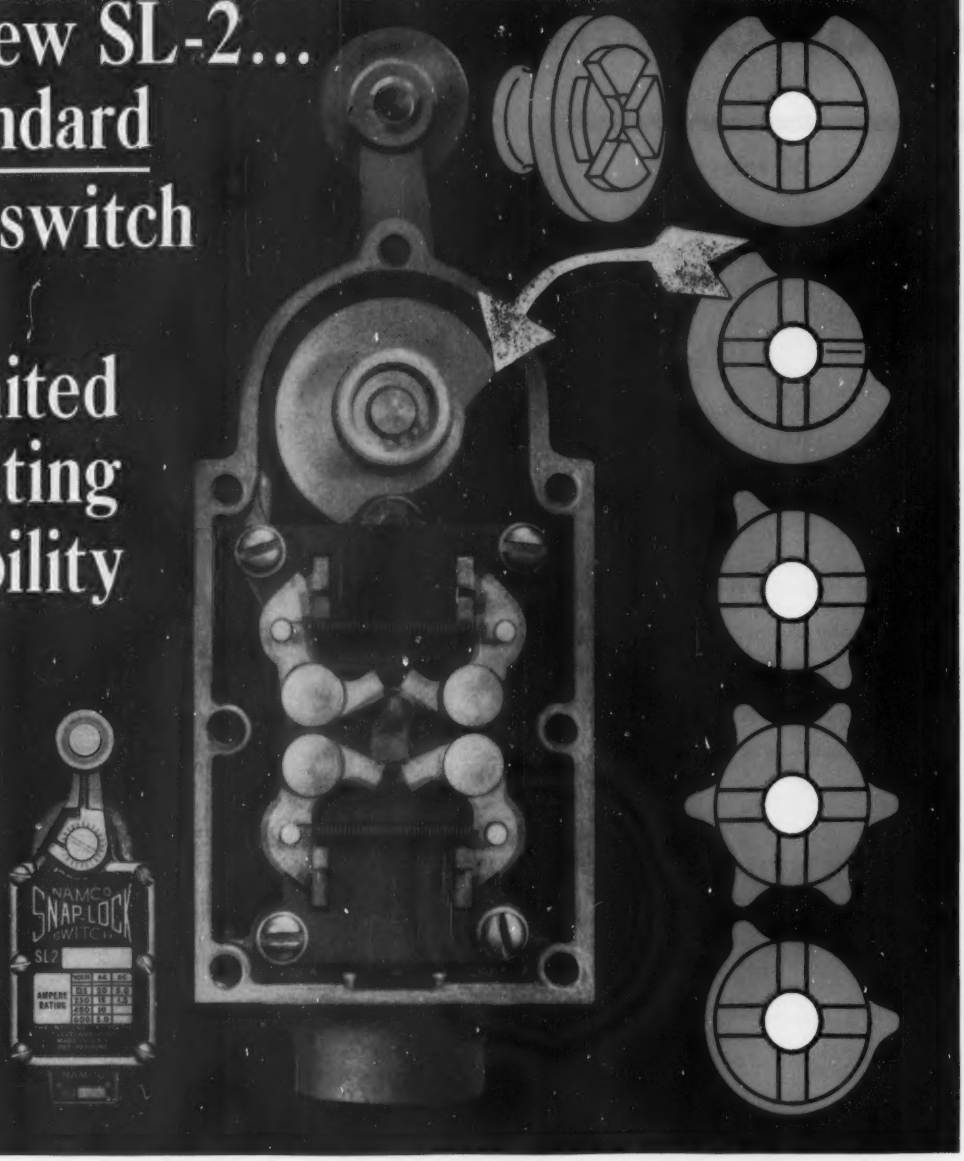
Company_____

Address_____

City_____ **State**_____

Circle 505 on Page 19

the new SL-2... a standard limit switch with unlimited operating flexibility



Tailor limit switch performance to your specific job with NAMCO'S *standard* SL-2. This "machine life" limit switch features a standard cam blank which can be cut into a wide variety of configurations to meet any application. These interchangeable cams provide positive control of contact sequence; let you match switch operation to your specific job. Ruggedly built, oil-tight and moisture-proof, the SL-2 provides dependable, accurate performance that meets your most precise requirements.

Now available for low-current, high-shock, excessive-vibration applications...the SLS-2... with full-wiping, self-cleaning sliding contacts that insure "everytime" operation under conditions that spell machine downtime for other limit switches.

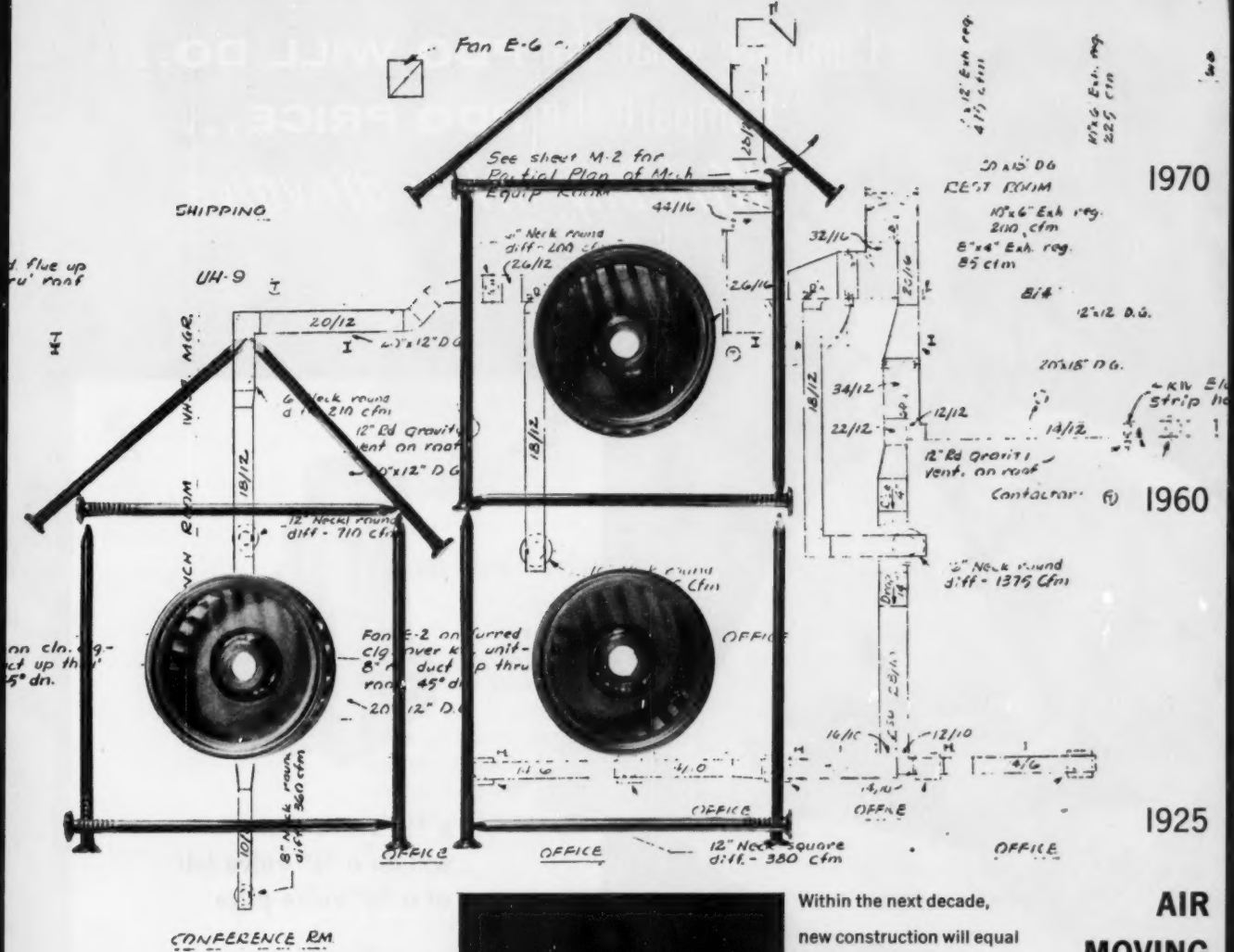
Get all the details on how the NAMCO SL-2 line eliminates limit switching problems for good. Write for Bulletin EC-SL260, or contact one of our representatives. You'll find them in all principal cities.

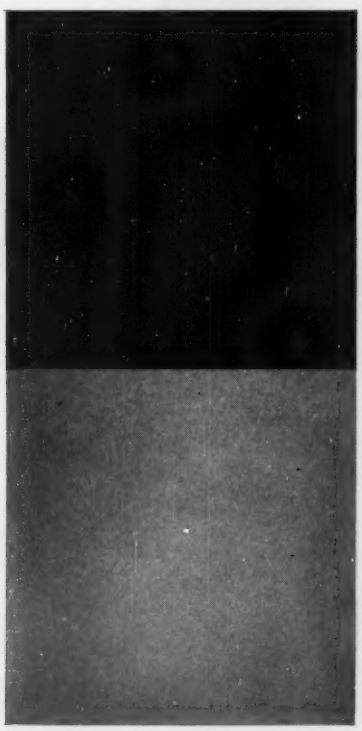
National Acme

THE NATIONAL ACME COMPANY
1[st] E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.

Circle 507 on Page 19





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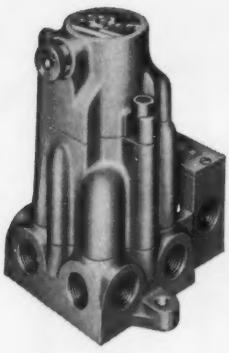
Within the next decade, new construction will equal in value the total U. S. building investment since 1925! **This means as many new ventilating, heating and air conditioning units as the air moving industry has produced in 35 years —and as many problems.** There is no better time than now to point out that Torrington's capabilities in the technology of moving air—and in the production of air moving components—are rated as the finest in the world.

THE TORRINGTON MANUFACTURING COMPANY

AIR MOVING DIVISIONS Torrington, Connecticut; Van Nuys, California; Rochester, Indiana; Oakville, Ontario

Circle 508 on Page 19

Compare what the **PDQ WILL DO...**
Compare the **PDQ PRICE...**
With any other air valve...



a ½" valve that will do a ¾" valve job at a ⅜" valve price

- ☑ Accessibility
- ☑ Simplicity
- ☑ Speed and Capacity
- ☑ Price and Quality

What will the PDQ do? It will do a ¾" valve job. It has faster response time and greater capacity than valves twice its size and four times its weight. To repack you simply replace 2 self-contained units in less than a minute. You can change valves on the line in less than 30 seconds.

Will the PDQ last? The PDQ has a short stroke, and a light but rugged aluminum construction with built-in wear compensation. Anticipated valve life is conservatively estimated at 35 million cycles . . . on most applications this is **years** of trouble-free service. Coil (properly applied) is unconditionally guaranteed for the life of the valve.

How about the price? The PDQ is a ½" valve at a ⅜" valve price. Write us today.

A. V. Ney

A. V. Ney, Sales Manager

HUNT VALVE COMPANY · SALEM, OHIO, U. S. A.

HUNT

Circle 509 on Page 19

Quick-As-Wink AIR & HYDRAULIC CONTROL VALVES

DESIGN
June 9, 1960

Wanted: Ideas

TOTAL area of the United States—with the recent addition of Alaska—is now also as great as that of Europe. But Europe has more than twice as many people. And the six nations comprising the so-called European Common Market have just about as many inhabitants as the entire United States.

For some time West Germany alone has outproduced us in machine tools. Now free Europe is pressing hard for the lead in automobile production. Hitherto we have prided ourselves as leaders in the design and production of these two highly engineered products.

With their lower costs — but equal, sometimes superior, quality— European countries can sell their products here even against the handicap of high tariffs. With the imminent removal of internal tariff barriers in Western Europe, how much chance have we to sell our goods in that tremendous market?

Our citizens buy European cars, Swiss watches, Japanese cameras, and Scotch whisky, because they like these products and the prices are within reach. Industry buys foreign production equipment, turbogenerators, and other products because they help produce goods or services at lower cost.

No great intelligence is needed to foresee the effects on employment and our standard of living if we lose much of our domestic market and cannot compensate by selling to the foreign markets. In some industries the situation is already critical.

We can't stop imports even if we wanted to. We have no choice but to meet competition head-on. This means we must improve our productivity so we can compete price-wise, and develop new products that will give us a competitive edge both at home and abroad.

The answer lies in the creative genius of our research, development, and design engineers. They hold the key in the struggle for economic survival. New ideas carefully researched and developed, then designed into hardware that can be sold in competition with the world's best, are our most powerful weapon.

Only thus can we hold our own in the face of European competition, to say nothing of competition from the Soviets and the Orient.

Colin Carmichael

EDITOR

A guide to selecting and specifying . . .

ORGANIC FINISHES

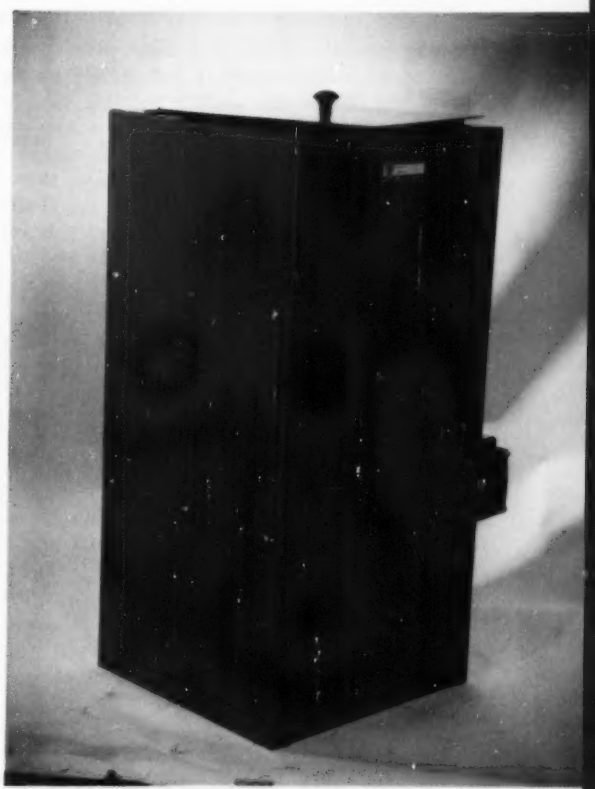
for metal surfaces

The design of an automobile, a bicycle, or a piece of industrial equipment is not complete until a proper finish is selected. Does the finish require chemical, oil, or water resistance? Or flexibility? Weather resistance? Toughness? How about appearance? No single coating can fulfill all of these qualities. Selection of a finish is usually a compromise of several ideal characteristics. Basic information on organic finishes —their selection, specification, required surface preparation, and application—is presented in this guide.

R. G. MURPHY
Chief Industrial Engineer
Wallace & Tiernan Inc.
Belleville, N. J.

Iridescent finish on Huffy bicycles starts with a coat of Glidden leafing-aluminum primer. Topcoat is a high-gloss transparent enamel. Both are applied electrostatically. Because color is affected by film thickness in this type of finish, close control is maintained in application.

Outside finish of this dry chemical feeder consists of an alkyd-urea baking primer (formulated to accept lacquer topcoats) and a nitrocellulose topcoat. To resist corrosive effects of dry chemicals and splashing of solutions, Wallace & Tiernan Inc. uses an asphalt bituminous finish inside.



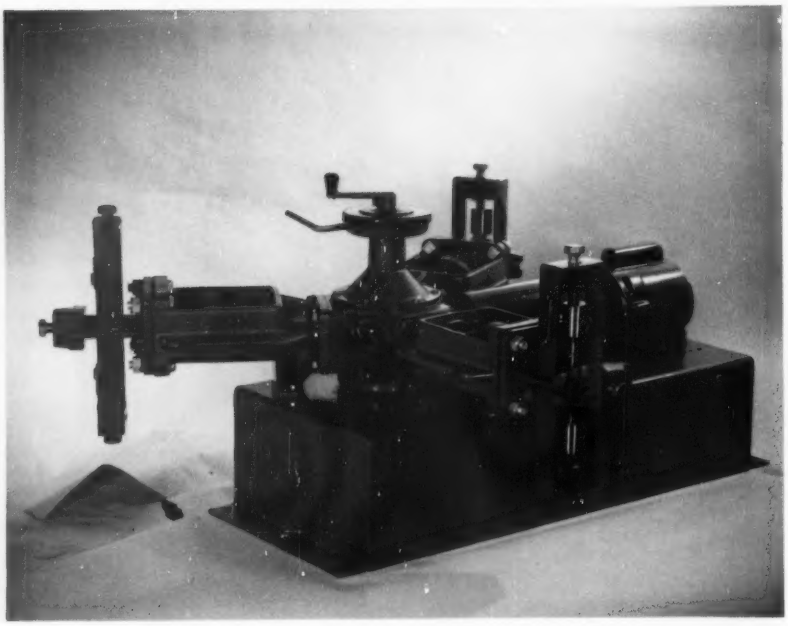
SELECTION of a protective and decorative coating for a product is as much a part of a good design as are the mechanical functions of the item. Organic finishes are used to furnish a wide variety of required surface characteristics. Thousands of formulations are feasible, permitting a finish to be tailored to specific physical and aesthetic requirements.

Organic Finishing Materials

All organic finishes are mixtures of two or more materials to make the complete finish. These materials are:

1. Vehicle or base, in which other components are suspended.
2. Pigment, to impart color and gloss.
3. Driers, to aid in drying or hardening of the vehicle.
4. Solvents, also called diluents, to reduce viscosity for ease of application.
5. Plasticizers, often added to make the dried film more flexible.
6. Extenders, to "bulk" the finish at a low cost while not affecting the final dried film.

Paint: Paint consists of linseed oil, pigment, and turpentine or other solvent to thin the mixture to



Metering pump is finished with a baked epoxy-amine enamel. Wallace & Tiernan Inc. uses this coating to resist corrosive acid solutions pumped.

brushing consistency. Drying takes place partially by evaporation of the solvent, but mainly by oxidation of the linseed oil. Certain metallic salts, such as manganese, lead, or cobalt are sometimes added to accelerate drying. Paint is the finish almost universally used to protect wooden structures since the dry film has excellent weather resistance. Paint is sometimes used to coat steel for exterior exposure such as on bridges, but it is not used in production finishing of equipment.

Shellac: Shellac is a solution of "lac" and alcohol. Lac, an excretion of small insects deposited on twigs of trees and bushes, is found mainly in India. It is collected and processed to remove foreign matter and then dried. Dissolved in alcohol, lac produces orange shellac. If the orange shellac is bleached and further treated, white shellac is obtained. Industrial uses for shellac are numerous but, as a coating for industrial goods for the consumer market, it is used only for finishing of wood products.

Shellac is a solvent-type finish which dries by evaporation of its solvent, alcohol.

Lacquer: The most important of the solvent-type finishes is lacquer. By definition, lacquer is "a film-forming material which dries by evaporation of a solvent." The advantage of the short drying period of lacquer finishes spurred their rapid development for the young automobile industry, eliminating production bottlenecks. Most lacquers are made of nitrocellulose dissolved in a solvent, with pigment added for color. Lacquers are modified with resins and plasticizers, Table 1, to improve toughness, water resistance, chemical resistance, adhesion, and resistance to heat.

Lacquers form a durable finish, are easy to apply, and they permit rapid production schedules. Pigments can be added to produce almost all colors.

Although normally a high-gloss finish, lacquer can be modified by the addition of metal soaps such as aluminum stearate, to produce any degree of gloss from high to dull. The drying time can be lengthened by addition of retarders to permit application by brush. Lacquers can be further modified with dammar resin to improve adhesion, or with alkyd resin to improve durability.

By definition, the lacquer group also includes the butadiene-styrene copolymer resins. These resins are dissolved in medium-strength solvents and make excellent concrete floor coatings and metal primers. Also included under the heading of lacquers are

Table 1—Characteristics of Modified Lacquers*

Modified Lacquer	Characteristics Improved
Ethyl cellulose	Alkali resistance
Cellulose acetate butyrate	Weather resistance
Styrene butadiene	Adhesion, chemical, and water resistance
Cellulose acetate	Heat and oil resistance
Vinyl	Toughness, abrasion, and oil resistance
Acrylic	Acid, alkali, and water resistance

*Compared with basic (nitrocellulose) lacquer.

acrylic-resin lacquer, vinyl lacquer, and styrene or polystyrene lacquer. All of these resins can be prepared as solvent-type finishes.

Varnish: Varnish is the term applied to a resin dissolved in and cooked with a drying oil. A suitable solvent is added to the mixture to reduce viscosity. Varnishes are clear materials, used as the vehicle or binder in enamels. Varnishes (and enamels) dry mainly by oxidation and/or polymerization of the vehicle, although some spirit varnishes dry by evaporation of solvent, leaving the resin as the film.

The resin may be natural or synthetic. Among the natural resins are Kauri gum, Congo gum, Manila gum, Batu, dammar, and amber. The synthetic resin field includes alkyd, phenolic, epoxy, silicone, urea, and melamine. The resin is cooked in combination with the drying oil which can be castor, soybean, fish, cottonseed, or corn oil.

Each type of oil and resin imparts certain characteristics to a dried organic finish. If one combination of resin and oil is too brittle but has other desirable characteristics, it can be modified by a small addition of another resin to reduce the undesirable quality.

Some resins are used not only to form basic vehicles but are used also as modifiers of other vehicles. Examples of these are alkyd modified with silicone, or alkyd modified with vinyl. On the other hand, some resins are not formulated as basic vehicles but are used solely as modifiers. This group includes urea and melamine which can be used to modify alkyd vehicles to improve their characteristics.

Characteristics of varnishes also may be varied by changing the ratio of resin to oil. The oil content is called "oil length." "Long oil" varnishes have a high percentage of oil and low percentage of resin and tend to exhibit the characteristics of the oil. "Short oil" varnishes have a low percentage of oil and a high percentage of resin and tend to exhibit the characteristics of the resin.

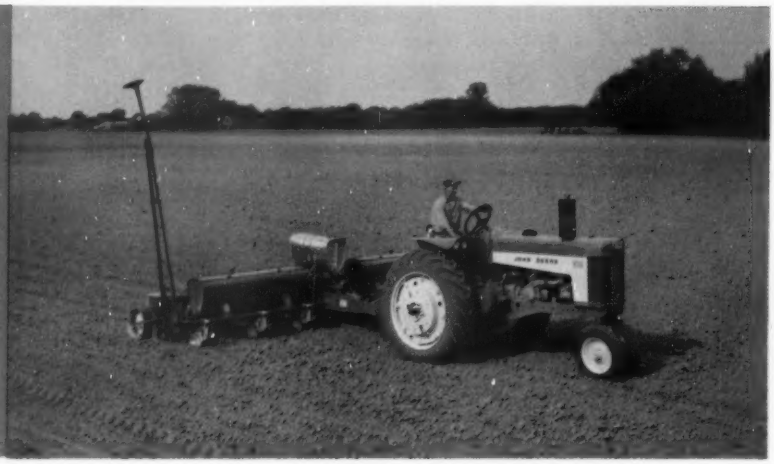
Enamel: When pigments are added to varnish, an enamel results. Enamels dry by oxidation and/or polymerization of the vehicle. Oxidation may take place by normal air drying, or by forced drying. Generally, polymerization is brought about by addition of a catalyst and/or by baking. Depending on the vehicle, the baking temperature may vary from 180 to 400 F. Generally, baking will produce a higher degree of a characteristic than an air-dry coating of equivalent formulation.

Gloss of enamels is controlled by the ratio of pigment to binder, type of pigments and extenders, flat-

Baked Porcelux enamel on Westinghouse dishwasher combines beauty with utility. Finish is glossy, durable, and easy to keep clean.

ORGANIC FINISHES

To produce a tough, weather-resistant surface and to assure uniform casting appearance an oil-modified alkyd-enamel finish is used on this John Deere tractor and planter. Parts are dip coated.



ting agents, and the fineness of the ground pigments. Gloss can be heightened by increasing the amount of binder, by decreasing the amount of flatting agent, and by using finely ground pigment.

Pigments used in enamels, lacquers, or paints not only add color to the product, they also add other desirable qualities. Pigments in linseed oil for example, extend the life of the dried film to many years. Pigments also increase film adhesion and aid in inhibiting corrosion.

A basic enamel vehicle made from a particular resin may lack certain desirable characteristics. These characteristics may be available from another resin used to form a different enamel vehicle. Often a small amount of one basic resin is added to another basic resin vehicle to obtain the desirable characteristics of the modifier. This is done without losing the good qualities of the original vehicle. For example, vinyl resin may be added to an alkyd vehicle to reduce air-drying time and to increase toughness and chemical resistance. While, in this case, vinyl is a modifier, it can be formulated also as a basic vehicle as shown in Table 2.

Other resins, however, are used almost exclusively as modifiers of basic resin vehicles. These include:

1. Urea and melamine: Used to formulate baking materials, improve color retention, heat resistance, hardness, mar resistance, and alkali resistance.
2. Coumarone-indene: Improves dielectric properties, water resistance, and gloss.

Enamels, both natural and synthetic, are the most used and the most versatile of the finishing materials. Enamels are available to meet almost all exposure conditions, in almost all colors and shades. They can be applied by a large variety of methods.

Emulsions: An emulsion finishing material consists of a suspension of oil and pigment in water. Water is the solvent. Emulsions have little or no odor, no fire hazard, and their use simplifies cleanup. Emulsion finishes have their widest use in house-

Table 2—Characteristics of Enamels

Enamel	General Characteristics
Alkyd	Excellent resistance to weathering, water, and chemicals. Excellent color and gloss retention. Modified by changing resin-to-oil ratio.
Alkyd phenolic	Improved water and chemical resistance over straight alkyd. Reduced flexibility, and color and gloss retention.
Alkyd styrene	Decreased air drying time over straight alkyd. Decreased abrasion resistance.
Alkyd silicone	Increased resistance to heat.
Epoxy esters	Approximately equal to straight alkyd.
Epoxy	Excellent chemical resistance, flexibility, and adhesion (including adhesion to plastics). modified with amine resins. Less gloss retention than alkyds. Baking required unless
Phenolic	Excellent chemical, water, and oil resistance. Baked finish can be submerged in water. Coating is brittle—modifiers improving brittleness can decrease other good characteristics.
Silicone	Outstanding heat resistance.
Urethane	Good dielectric properties. Abrasion resistant.
Vinyl	Excellent water resistance.
Acrylic	Resists discoloration at high temperatures. High temperature required for curing.

hold applications, but their use in industrial finishing is increasing. They dry by evaporation of the water, leaving the binder and pigment to form the film. Certain resins not readily soluble can be formulated as emulsion coatings.

Bituminous Paints: Coal-tar bituminous paint is a solvent-type material in which coal tar is dissolved. The solvent evaporates, leaving the bituminous film. Various grades of coal-tar materials are available with and without inert fillers. The fillers permit application of heavier coats for thermal insulation or sound-deadening films, as used for automobile undercoating.

Coal-tar paints have extremely low permeability and consequent high resistance to water. They afford excellent protection on items to be submerged constantly. However, when exposed to the sun, the film buckles and cracks. This is called "alligatoring."

Coal-tar materials can also be formulated as emulsions but, because of inadequate sealing of the binder, they do not offer as much protection as do the solvent-type coal-tar paints.

Asphalt paints are also in the bituminous group of solvent-type coatings. They are more weather and sunlight-resistant than coal-tar paints, but do not have as high a water resistance. Because of the mild solvents used, asphalt paints are often used to paint the interior of drinking-water storage tanks.

The bituminous materials not only provide excellent water resistance but also good resistance to weak acids, alkalies, and salts. Because the basic ingredient is black, they cannot be pigmented to obtain light colors. The dried film does not present as pleasing an appearance as do lacquers and enamels. Use of these materials is therefore limited to protective rather than decorative applications.

Rubber Base Coatings: The three important types of rubber base coatings are chlorinated rubber, neoprene, and Hypalon.

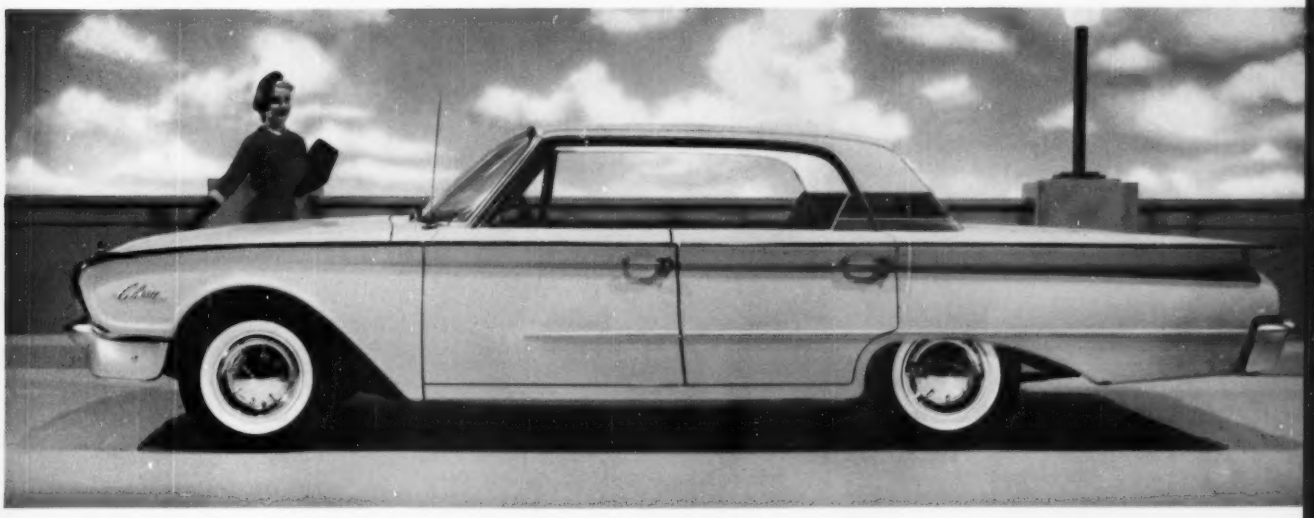
CHLORINATED-RUBBER materials not modified with oxidizing resins fall in the lacquer category, since they dry by evaporation of the solvent. Many materials on the market are called "chlorinated-rubber paint" but the actual chlorinated-rubber content may vary from 5 to 80 per cent. A 100 per cent chlorinated rubber is unsuitable as a coating because of brittleness, poor adhesion, and lack of toughness. The material must be modified with plasticizers and resins such as alkyds, phenolics, and maleics. Generally, the more the modification, the less the characteristics of the chlorinated rubber in the dry film. To retain the best characteristics of this material, not less than 60 per cent of the vehicle solids should be chlorinated rubber. The modifiers should, of course, add to the resistance of the dried film.

The outstanding characteristic of good chlorinated-rubber materials is resistance to water. These materials are often used on submerged metal or on metal subject to splash or spillage. Chlorinated-rubber paints also resist acids, alkalies, salts, alcohol, gasoline, and mineral oil, and have excellent dielectric properties. They are not resistant to animal or vegetable oils or greases.

Chlorinated-rubber paints are limited in the range of colors available and are generally used as protective rather than decorative finishes. Because of the problem of compatibility with oil-base finishes, they are rarely used over other types of coatings. A complete system of primer, intermediate coats and top coats, all formulated of chlorinated rubber, is usually used.

NEOPRENE coatings consist of neoprene dissolved in a solvent. They dry by evaporation of the solvent and leave a film that is outstanding in its chemical

Two coats of epoxy-resin primer form the initial bond to the phosphated-steel body of this 1960 Ford Galaxie hardtop. Two topcoats of synthetic Diamond Lustre enamel complete the hard-surfaced finish.



ORGANIC FINISHES

A pigmented cellulose-acetate-butyrate lacquer (dope) over the predoped fabric of this Champion lightplane produces a flexible and weather-resistant surface. Glidden vinyl washcoat primer and zinc-chromate primer are used on aluminum and steel parts respectively. Topcoats are air-drying alkyd enamels.

resistance to alkalies, many organic and inorganic acids, aliphatic hydrocarbons, alcohol, many salts, and natural oils. The film is not resistant to oxidizing agents, but does resist heat up to 200 F.

Generally, neoprene coatings are available in two types. In both cases the solvent evaporates leaving the film-forming ingredients. In one type, the curing requires two weeks to reach maximum resistance; in the second type, vulcanizing agents are added to speed the curing time to a matter of hours.

HYPALON (chlorosulfonated polyethylene) is a third type of rubber coating whose outstanding property is resistance to oxidizing agents. Various formulations of Hypalon also resist temperature deterioration from −80 to 300 F. Available colors are almost unlimited.

Undercoats: The majority of the materials previously described serve mainly as topcoats and offer chemical and physical resistance to attacks on the surface of a finish film. However, these topcoats usually supply neither the necessary bond to the material being finished, the required filling characteristics, nor the corrosion resistance required directly at the metal surface. To perform these functions, primers, primer-surfacers, and surfacers are used. These materials must also "hold out" or support, but not absorb, the topcoat materials.

Generally, the undercoat materials are of the enamel type, although some solvent-type primers are used. The three types of undercoaters differ in the pigment-to-binder ratio. Primers, having the lowest ratio, produce the best bond to the substrate, the lowest degree of filling of the substrate and are the most difficult to sand. Primer-surfacers, having a higher ratio, produce better sanding qualities, better filling of surface defects, but less bond than primers. Surfacers give the best filling and sanding qualities, but the least bond. A complete finish system of the highest quality might consist of a primer, a surfacer, and one or more topcoats.

To provide the best bond to the substrate and the best corrosion resistance, certain ingredients are added to a basic enamel formulation to produce the undercoaters. This does not mean that an enamel can be made into a primer, but that undercoats have the same type of formulation. To obtain water resistance, raw materials such as phenolic resin, china wood oil, oiticica oil, or zinc oxide are added to the formula. To obtain corrosion resistance, pigments such as zinc chromate, lead oxide, lead chromate, or basic blue lead sulfate are added.

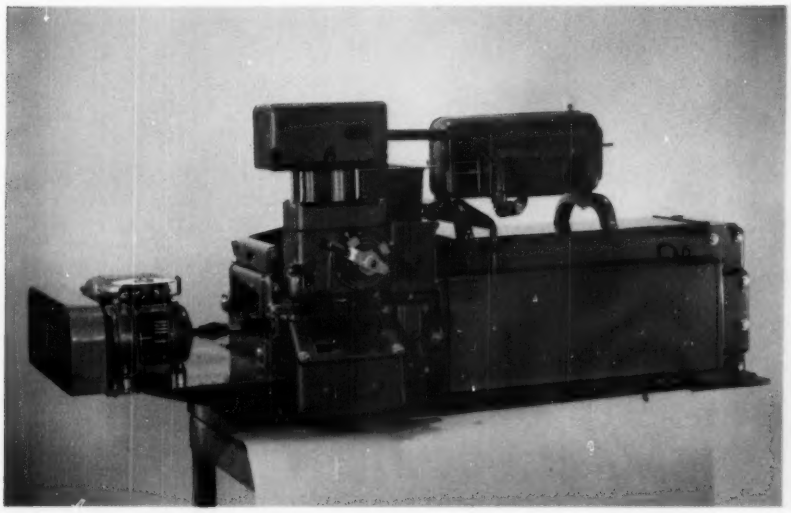
Novelty Finishes: Certain topcoat finishing materials which produce special decorative effects are called "novelty" finishes.

WRINKLES are prepared as oil base or alkyd-resin enamels without amines and must be baked to produce the wrinkle effect. Available colors in wrinkle enamels do not include pastel shades which would yellow during baking. Wrinkle enamels are applied as a single coat. They are designed to hide surface defects without requiring the use of heavy surfacers and fillers. Patterns are available from fine to coarse. Wrinkle finishes have the same resistance characteristics as the enamel vehicle.

HAMMER FINISHES were also originally designed to hide defects in the substrate without the high cost of filling, surfacing, and sanding. Solvent-type finishes are available, but hammer finishers are generally in the enamel family and contain an alkyd-resin vehicle. The hammered effect comes from the addition of nonleafing aluminum powder to the formulation. Two types of hammer-finish systems are available:

1. A two-application process in which the ground coat is sprayed on, allowed to set, then spattered with thinner to produce the hammered effect.
2. A one-coat system in which the pattern develops as the material sets. This type requires more skill to apply but represents a saving of time.

In either case, the material can be formulated



Hammered finish of alkyd-urea baking enamel produces both chemical resistance and a decorative effect on this Wallace & Tiernan Gravimetric chemical feeder.

for air drying or for baking.

IRIDESCENT MATERIALS also contain nonleafing aluminum powder in a solvent-type vehicle. The vehicle is selected to produce a rapid setting of the film to resist the collection of the aluminum powder which would produce a hammer or metallic finish. Pearl essence is also used in iridescent finishes in place of aluminum powder.

Materials Compatibility

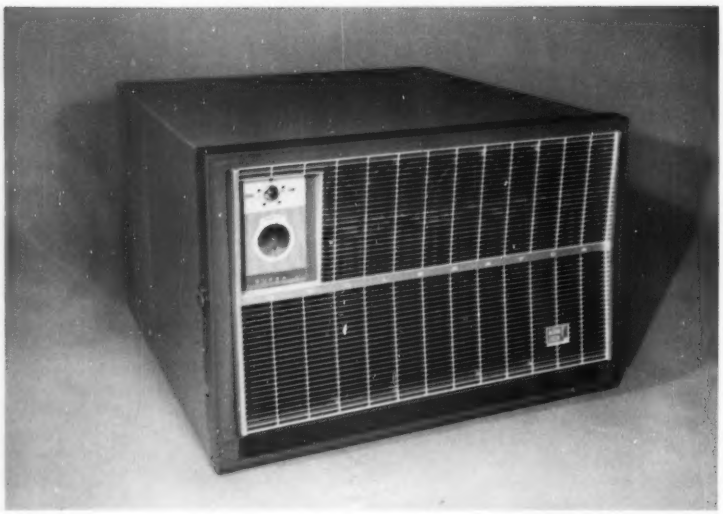
Finishes use a variety of solvents, each having a different "solvency value." Generally, a material containing a high-powered solvent should not be applied over a material which uses a low-powered solvent. For example, lacquer thinner is high powered. If a lacquer is applied to a film of air-dried enamel, wrinkling and blistering of the film results as the lacquer thinner bites into and dissolves the undercoats. This condition can usually be accommodated by applying a dry (minimum solvent) lacquer coat. When an air-dry enamel has been on an item for six months or more, the film may be sufficiently dry to resist the lacquer solvent, but the compatibility should be tested first.

On the other hand, a baked-enamel finish may be so hard that the solvent in an overcoat of lacquer or air-dry enamel will have little effect, resulting in poor adhesion between the baked enamel and the new topcoat. Compensation for this condition often is made by applying an extremely wet (excess solvent) topcoat.

Bituminous coatings as undercoats are not compatible with other oil-based finishes since the coal tar or asphalt bleeds through these materials and destroys the topcoat color. Cracking of the oil-base topcoats also occurs. However, bituminous coatings can be applied over old oil-base coatings that are tightly adhered to the substrate.

The need for touch-up and field repainting often makes a double finish selection necessary. For ex-

For resistance to sunlight and weathering, this Wallace & Tiernan lantern is finished with an alkyd-urea baking enamel.



Two coats of baked enamel give this 1960 Coolerator room air conditioner a pleasing and hard-wearing surface.

ample, baked epoxy-urea enamel may have all the required properties, but it cannot be touched up conveniently in production or reapplied in the field. A compatible air-dry material whose properties approach those of the baked enamel must also be selected to fit these needs.

Lacquers generally present the least problem of touch-up and repainting, air-dry enamels next, baked enamels the greatest. For field repainting of lacquers when production application methods are not available, brushing lacquers, containing low-volatile solvents are used.

With the increase in color consciousness of the consumer, overpainting (to change color) has become a significant problem. Again, lacquers (solvent-type materials) present the least difficulties. Air-dry enamels can also be used, but longer drying times permit dust particles to settle on the wet film, possibly marring the final finish. Baking enamels present a problem on some assembled equipment containing parts which cannot be heated above certain temperatures. Often an air-dry enamel can be used to overcoat a baked enamel, but then certain desired characteristics of the baked topcoat are lost.

Finish Specification

After the type and color of material are selected for a product, specifications are written to transmit this information to the finishing department.

Many methods are used in writing such specifications, ranging from simple to elaborate. The simplest specification puts the greatest reliance on the knowledge of the finishing foreman. If a large variety of material types are used, the shop foreman will have to keep records of materials and thinners available. If only a few materials are used in a shop, a simple specification will suffice. Such a specification might read: "Finish blue color number 87."

This leaves the selection of primer, thinners, coating thickness, method of application, and drying method all in the hands of the shop foreman. For a few stock materials being applied on a few items, such a specification might be sufficient. However, it will leave an inspection department at a loss unless it inspects only final color and appearance.

An elaborate specification can be prepared which leaves nothing in the hands of the shop foreman. Such a specification would include: Type and color of primer, surfacer and topcoat, thinners to be used, viscosity of material, tank and gun pressures, drying schedules, dry-film thickness tolerances, and a reference to a standard for final appearance.

Such a specification is usually too rigid when a large number of finishing materials are available, to be applied to a number of different substrates. Generally, a finishing shop uses one or two methods of applying a finish. The production method essentially fixes the thickness of each coat. Viscosity for application depends on a number of factors, including production methods, and is often left to the discretion of the shop foreman.

Perhaps the best specification for most industries is one which fixes the type and color of the topcoat, specifies a final grade of appearance to a prepared standard, and provides optional primers, primer-surfacers, and surfacers for a compatible system. For record and reference purposes, the specification sheet can also include proper thinners for the finishing materials and the drying method.

Each specification sheet for a color and type of topcoat is assigned a file number. The grade of finish may be coded in this specification number or may simply be termed grade 1, grade 2, etc. The grade specifies the appearance of the final film, and leaves to the judgment of the shop foreman the amount of surfacer and filler required to hide blemishes in the substrate.

A specification of a grade 2 finish for a single

Fig. 1—Typical finish specification sheet. Numbers are assigned to the various finishing materials to eliminate repetition of descriptions.

piece of equipment will result in a uniform appearance on the complete equipment in which the substrates may be castings, sheet metal, forgings, stampings, or extrusions. The sheet should list suitable primers for various types of substrates, to be selected by the shop foreman to suit the material. Since the condition of surfaces may vary in a job shop, the specification should not be so rigid that the finishing department cannot vary procedures to suit these conditions.

A specific but still flexible instruction can be prepared as shown in Fig. 1. Permanent standards can be prepared for the design department, finishing shop, and inspection departments. These standards represent minimum requirements.

For proper stock control and for elimination of description repetitions, identifying numbers are assigned to the various finishing materials. This number relates to a specification sheet for the individual materials.

Finishing Costs

The cost of an organic finish is not what the purchasing department pays for a gallon of material. The cost is computed from the coverage obtained from the material, and the amount of thinner required to reduce the viscosity to a point where the finish can be conveniently applied. The coverage is expressed in square feet per gallon at a specified thickness. Thickness is specified in mils (thousandths of an inch).

For example, most synthetic enamels have a solids content of about 65 per cent, apply at 1 mil per

coat, and are reduced about 10 per cent for spraying. Thinner costs about $.35 per gal. On the other hand, a lacquer, which permits rapid production schedules, has about 35 per cent solids, requires a 1 to 1 reduction of a thinner costing about $1 per gal, and applies at a rate of 0.5 mil per coat. To obtain the same thickness of film, two coats of lacquer must be applied to equal one coat of enamel.

The major cost in a finishing system lies in the application of the film, the handling, sanding, etc., and not in the actual organic finish itself.

Surface Preparation — Ferrous

Selection of a proper finishing material is not the final answer to a successful organic finish. The film must be applied to a substrate which has been cleaned and otherwise prepared to produce the maximum adhesion of the film to the surface.

Surface preparation of any metal should be divided into: 1. Cleaning. 2. Surface treatment.

Cleaning includes the removal of all oils, greases, perspiration, occlusions from castings, and rust from ferrous surfaces.

The removal of rust from iron and steel surfaces is accomplished by abrasion cleaning, sandblasting, or flame cleaning. Abrasion cleaning involves scratching of the surface with sandpaper or a wire brush. Flame cleaning is used to remove heavy deposits of rust, generally from structural steel. Both processes provide some surface preparation, but neither is as satisfactory as sandblasting. In addition to removing oxides and scale from steel shapes and iron castings, sandblasting also provides some measure of cleaning, that is, removal of oils and greases. If no further cleaning or surface preparation is to be done after sandblasting, the item should be primed immediately. If not primed in a short period of time, the virgin steel will oxidize due to humidity in the air.

Removal of oils and greases from ferrous surfaces is done with solvents, alkalies, emulsions, or acids.

Solvent Cleaning: Vapor-degreasing systems are generally used today for solvent cleaning of metals. A quantity of solvent is placed in a heated tank. Vapors boil from the surface of the liquid and dissolve the oil and grease from the part being cleaned. Suitable cooling coils and traps prevent the escape of the vapors. This process is good for removing heavy oil films but its cost is relatively high and it does not provide corrosion resistance.

Alkali Cleaning: The equipment used for alkali cleaning usually consists of dip tanks and/or spray washers. This system uses a blend of alkaline salts, soaps, and a neutralizer as the cleaning agent. Cost is low, but a thorough final rinse of parts is required to remove all alkali which would degrade the paint film. Parts cleaned in an alkali cleaner, as with sandblasted parts, should be primed immediately to prevent the formation of rust.

Emulsion Cleaning: Dip tanks and spray washers are also used for emulsion cleaning. The solution consists of a blend of petroleum products and emulsifying agents. While the process is relatively inexpensive, it usually leaves a microfilm of oil on the surface which detracts from the bond of the organic film.

Acid Cleaning: This process is generally used in steel mills for the removal of rust and scale. The solution is sulfuric, nitric, or hydrochloric acid. The process removes rust but leaves a surface not entirely suitable as a base for paint—a water-soluble iron salt residue remains.

General Comparisons—Lacquers and Enamels

Characteristic	Lacquers	Enamels
Speed of drying	Rapid—30 min	Air dry—2 to 12 hr; bake—15 min to 2 hr
Application method	Spray (sometimes dip or flowcoat)	Spray, dip, flowcoat, or roller coat
Coverage (at 1 mil)	200 sq ft per gal	450 sq ft per gal
Solvent	Volatile	Less volatile than lacquer; about 1/3 the cost
Color selection	Unlimited	Unlimited (for most enamels)
Color retention	Excellent	Slightly inferior to lacquer
Water resistance	Good	Good
Chemical resistance	Good	Slightly better than lacquer; some special formulations, excellent
Gloss range	High to flat	Glossy to dull
Flexibility	Excellent	Excellent
Abrasion resistance	Good	Very good
Heat resistance	170 F maximum	Dependent on vehicle, 250 to 500 F; silicone enamels to 1000 F
Overcoating	With lacquers, excellent; with enamels, good	With lacquers, poor; with enamels, very good
Exterior durability	Excellent	Very good to excellent

This problem has been alleviated by the use of phosphoric acid which leaves an iron phosphate (not water soluble) on the surface of the steel.

Another cleaning solution consists of alcohol, phosphoric acid, and water. This solution, used in manual cleaning systems, leaves a corrosion-inhibiting phosphate coating on the part.

Phosphating: The surface preparation for iron and steel most widely used today is phosphating. The process consists of cleaning, water rinsing, phosphating, and a sealing of the surface in dilute chromic acid. The phosphating is accomplished by a solution of acid-phosphate salts or phosphoric acid. The salts deposit on the surface, producing a crystalline structure, and the phosphoric acid reacts with the metal to form an amorphous phosphate.

Surface Preparation — Nonferrous

Aluminum: Solvents, emulsions, or phosphoric-acid cleaners can be used to clean aluminum. Alkali cleaning can be used but strong caustics will seriously attack aluminum.

Aluminum oxide, which forms naturally on the surface of the metal, is an excellent base for a finish. The cleaning process should not remove this oxide. The formation of the oxide film can be accelerated and controlled by the anodizing process.

Oxide films are also produced chemically in heated chromate baths. The article is immersed in or is sprayed with hot chromate, which forms a uniform oxide film. Both of these methods produce surfaces which provide excellent finish adhesion.

Zinc: Among the more difficult metals to prepare for finishing is zinc. Zinc reacts with an organic film to form soap which breaks down the film and causes failure. The most effective process consists of a phosphoric acid cleaning followed by a surface treatment of zinc phosphate. This over-all process is also applicable to steel and aluminum.

Copper: The most generally used surface treatment for copper and copper alloys is a conversion of the metallic surface to copper oxide. This oxide serves as an excellent base for paint. Copper can also be cleaned in emulsion cleaners and rinsed in a detergent to remove the micro-oil film.

Finish Application Methods

Spray Painting: The most common method of industrial finishing is spray painting. A number of adaptations of this basic principle have been developed which include airless, electrostatic, steam, and hot spraying.

AIRLESS SPRAYING uses high pressure (300 to 2000 psi) to force the finishing liquid to the nozzle where it is atomized in the high-velocity discharge. To assist the flow of material, it may be previously heated to decrease its viscosity. This system decreases the overspray common to normal spray painting.

ELECTROSTATIC SPRAYING uses a basic air-spraying system with an electrostatic charge on the article being finished. The charge attracts the particles of lacquer or enamel. Overspray is almost eliminated and excellent coverage of the article results. Although initial equipment costs are high, this system requires a minimum of operator attention.

STEAM SPRAYING substitutes superheated steam for compressed air. This process provides good coverage in closed areas. The superheated steam volume decreases as it leaves the nozzle and prevents "blow back" and overspray. The principle is the opposite of compressed air which expands as it leaves the spray nozzle. The steam escaping from the spray nozzle will not burn the operator, although insulation is required on the gun.

HOT SPRAYING substitutes heat for a solvent to reduce the viscosity of the sprayed material. Other methods reduce the viscosity with solvents. Solvents are expensive, and must later be evaporated from the deposited film.

Dip Coating: With this method the article is immersed in a tank of the finishing material, extracted, and the excess material is allowed to drip off. The dip tank requires a volume of material which will often limit the use of the process unless high production rates are involved.

Lacquers can be used for dipping, but because of the high volatility of lacquers, the process is usually limited to enamels.

If the dip process is in use in a plant, products must be designed for dipping. The articles must be free of pockets which trap air and prevent coating. Design must also permit free flow of the excess finish during the dripping cycle.

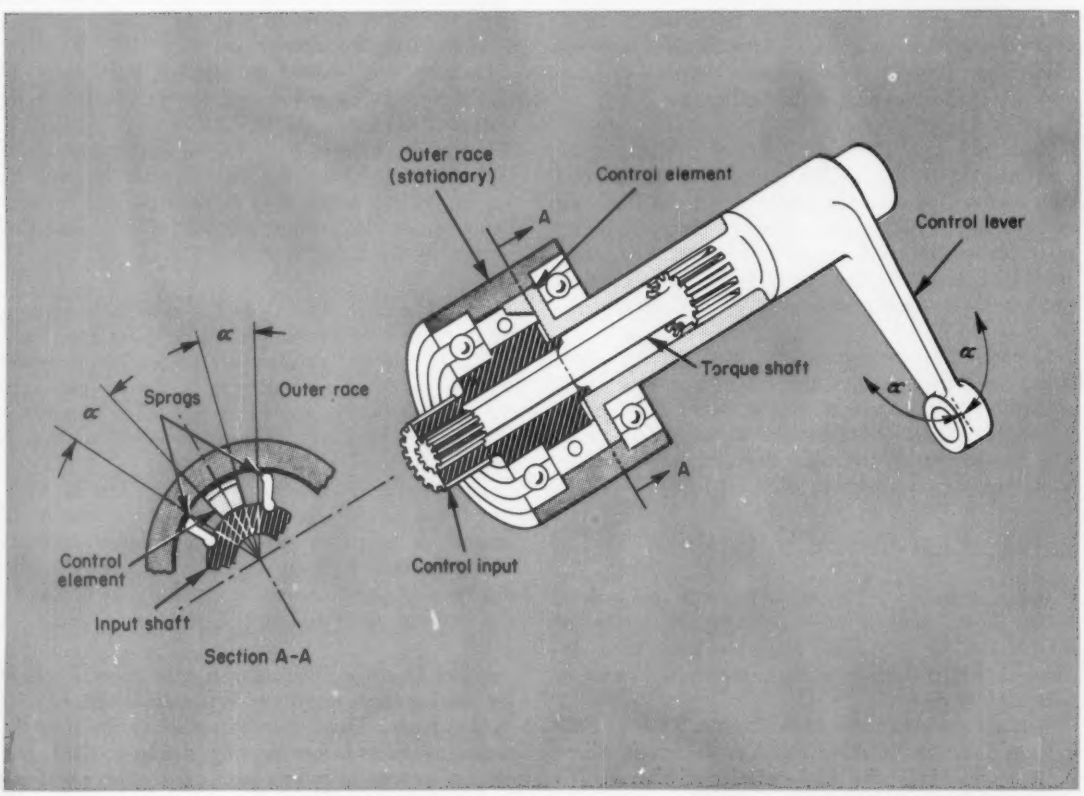
Flow Coating: The flow-coat process is used in conjunction with a conveyorized finishing line. Parts hanging from the conveyor are passed into a tunnel where the finishing material is flowed onto the pieces. Flow nozzles apply it to the article in streams. The excess runs off, returns to a sump, and is pumped back to the nozzles.

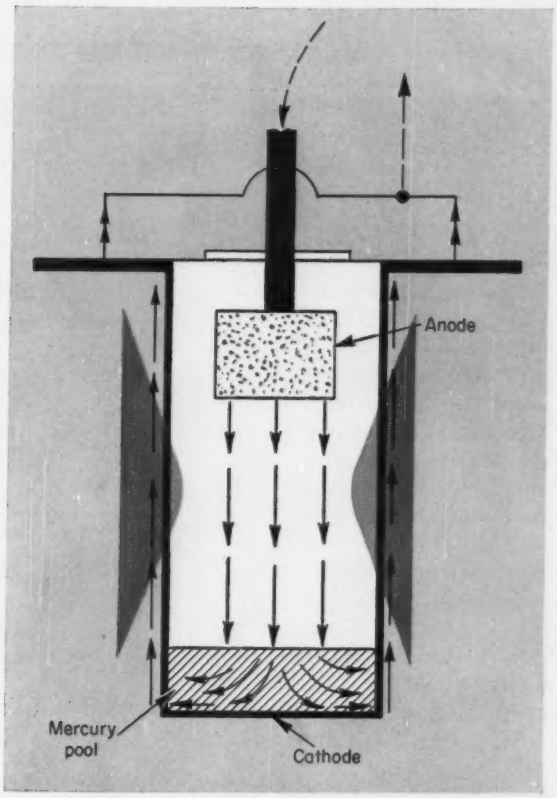
The process is efficient in reducing loss by overspray and provides good coverage. Flow coating of enamels is most common because of lower volatility of the enamels as compared with lacquers. As with dip coating, parts must be carefully designed for this method of finishing.

Roller Coating: The roller-coating process is used for coating sheet metal and is not applicable to odd-shaped parts. The finish is applied to the sheet by means of rollers before forming, similar to the homeowners' process of rolling paint on a plaster wall.

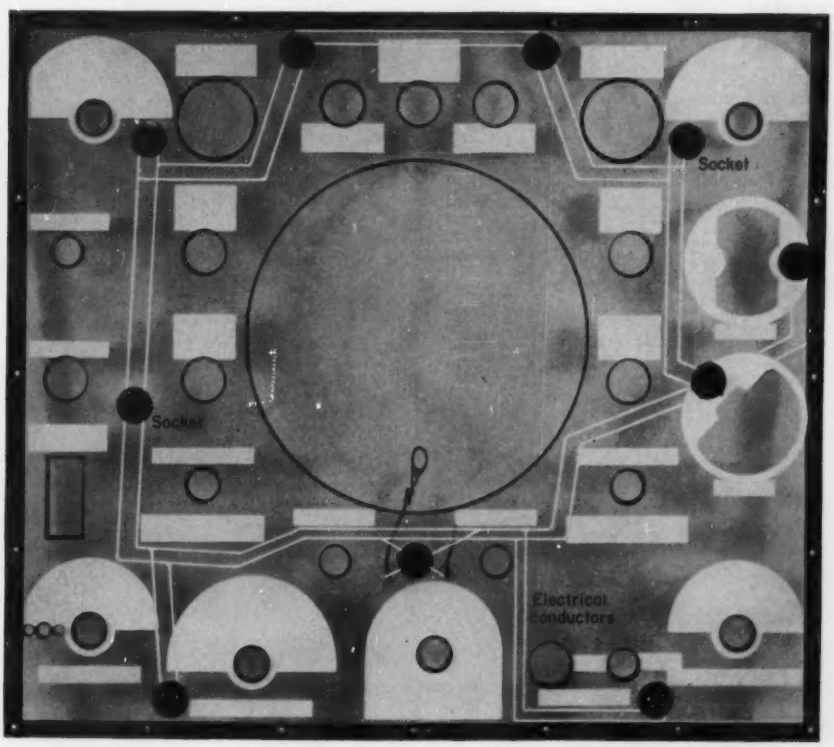
scanning the field for *ideas*

Torque-shaft windup limits torque transmission by actuating a sprag-type clutch. Two halves of the clutch are keyed to a common shaft. In normal operation, sprags clear stationary outer race. At predetermined torque, angular deflection of the shaft actuates control elements to engage sprags with stationary outer race. Torque-sensing device developed by Formsprag Co., Warren, Mich.



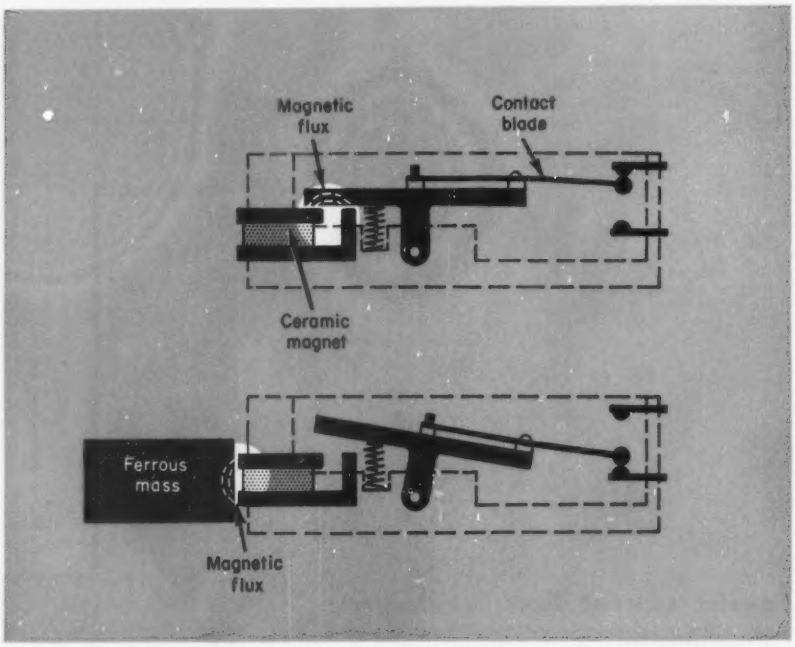


Coaxial current flow in ignitron tube exerts a pinching or confining force on the ionized area between the anode and the cathode pool, thus preventing conduction to the inside jacket. Principle employed in ignitron tube developed by General Electric Co. for Robotron Corp., Detroit.

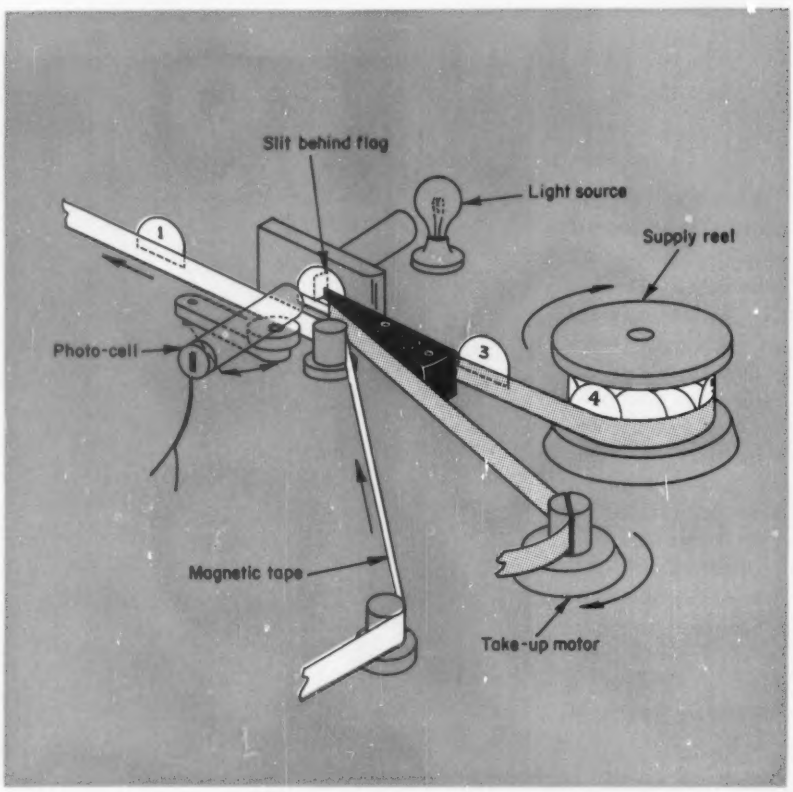


"Wireless" light-conducting panel simplifies wiring of bulb sockets. Conductors in channels, or silk - screened circuit printed directly on the transparent plastic panel, distribute power to bulbs for edge-lighting. A second indicia panel is installed in front of the light-conducting panel. Principles employed in visual displays developed by U. S. Naval Engineering Experiment Station, Annapolis, Md.

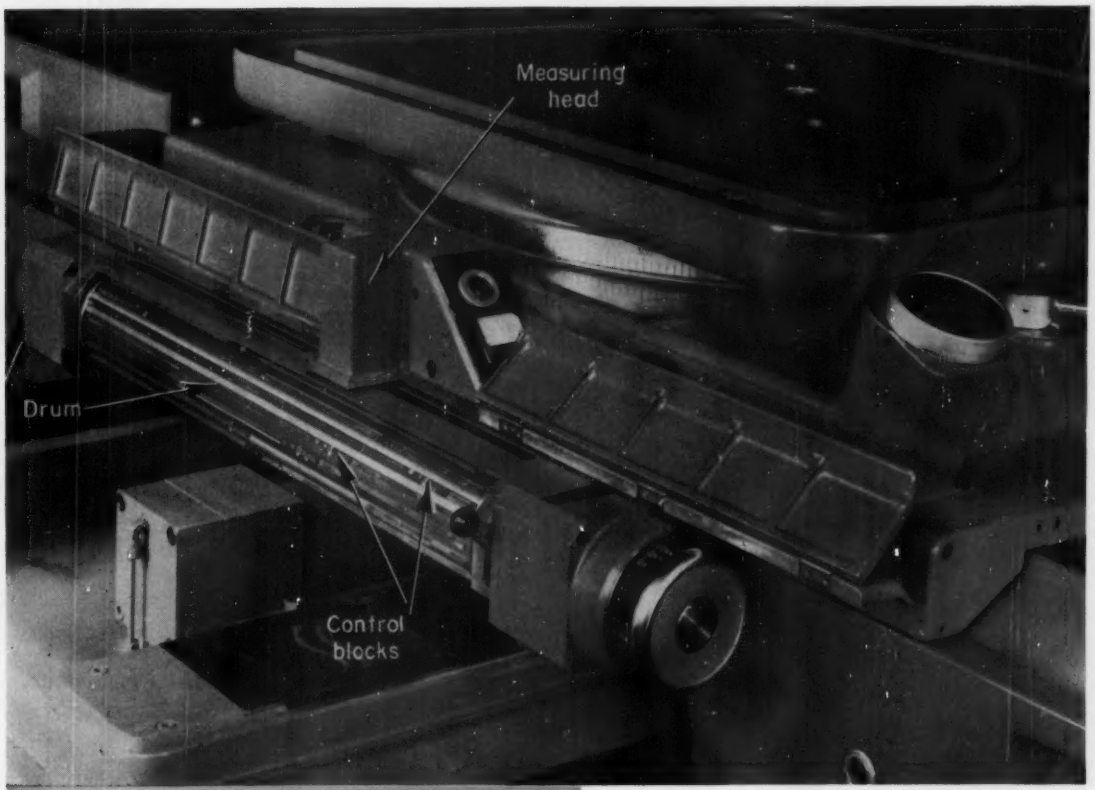
Official U. S. Navy photograph.

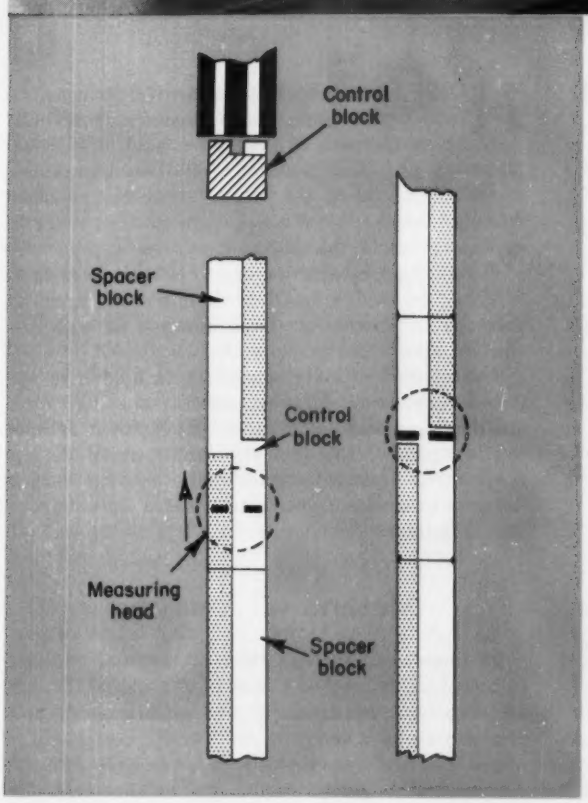


Magnetic flux detour through detected object trips proximity switch. The switch is normally held in the closed position by magnetic attraction between switch arm and magnet. When a ferrous mass approaches the magnet, lines of flux pass through the mass, thus releasing switch arm. Spring force then opens switch. Principle employed in switch developed by Tann Corp., Detroit.



Persistent - label peeler pulls supporting tape around sharp corner for separation. The projecting label then interrupts a light beam to halt drive motor and actuate a roller and arm to complete transfer of adhesive - backed label to receiving tape. Principle employed in tape-indexing machine developed by Datrel Inc., Hempstead, N. Y.





Quick-change stops are combined with capacitance sensors to provide easily adjusted, accurate control of table travel. A control block is positioned in a groove to actuate measuring head. Remainder of groove length accepts spacer blocks. Elevation of block on either right or left side controls travel direction. Vernier adjustments permit accurate position of the control block. A rotating drum provides 24 grooves for blocks, to control successive positionings. Principle employed in jig borer developed by Dixi SA, Le Locle, Switzerland.

Accuracy of response becomes increasingly critical with more precise mechanisms. Here's a tabular method of

ERROR ANALYSIS

. . . using vector addition to evaluate system accuracy in the early stages of design

HOW well will a design compare in performance with its intended or desired function? Or, more conveniently, by how much will it fail to match the ideal performance? The answer becomes more vital as the desired precision increases. And, for very practical reasons, the answer ought to be known while the design is still on paper.

Evaluating probable performance error requires: 1. Detection and estimation of individual errors in parts or subassemblies. 2. Calculation of their influence upon total performance.

The method of error analysis presented here applies for any noncontinuous system—one that operates between definite limits or returns to a definite starting point. Examples are cam-operated devices or four-bar linkage systems. The method cannot be used to evaluate gear trains which operate continuously in one direction.

Method of Analysis

The mathematical technique of vectorial addition is used in this method. Besides the source of each error, the two important factors are magnitude and direction of each error.

Source: The sources of the predominant errors in

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any mechanism are usually obvious. Many of the errors result from inaccuracy of critical parts. Ball bearings introduce end-play and eccentricity errors. Gears have backlash. The inertia of fast moving parts may introduce deflection in shafts, levers, or frame. High acceleration may introduce other deflections. Dissimilar metals may introduce errors because of differential expansion.

Magnitude: The magnitude of each error must be determined or estimated. Magnitude is considered as the maximum possible deviation from a theoretically perfect position. The tolerance on machining dimensions defines the maximum deviation for machining error. For purchased components, the manufacturer's catalog is a ready source of tolerance information. If facts are not available concerning the magnitude of an error, a realistic estimate must be made.

Direction: A system of three co-ordinate axes is used to establish the direction of each error. One of the axes is made to coincide with the axis of rotation of the principal member. Usually, the predominant sources will fall on this axis. Another axis is made to intersect the center of some secondary member, such as an electrical transducer. The direction of the third axis is automatically determined. The origin can be made to coincide with the starting point of the noncontinuous mechanism. The exact location of the three co-ordinate axes is not critical.

Practical Examples

One simplified example and three full-system examples are shown. The latter present detailed analyses of the errors in three different types of control mechanisms. Design requirements are defined by the following performance characteristics:

1. The desired program will be selected or recorded by remote control.
2. Equipment is to be fully automatic and capable of recycling by remote control.
3. Equipment is airborne and subject to the usual environmental requirements, with special emphasis on its ability to perform satisfactorily under the vibration existing during the launching period.
4. The command signal will be analog.

The magnitude and direction of each error are tabulated as in the simplified example. Each source will have a magnitude directed along one or two axes, but rarely along all three axes. If an error is unidirectional, the magnitude is inserted under the

proper axis only. Errors due to placement are usually unidirectional. Errors due to radial looseness in ball bearings will occur in two directions.

Shaft rotational eccentricity due to ball bearings appears to be a unidirectional error. However, the position of maximum eccentricity is usually located at random on the shaft. If the eccentricity of one bearing is at 90 deg to the other, the shaft will wobble. Since this error can exist in either of two directions, it is inserted for both. Likewise, eccentricity of the outer rares will cause errors in shaft placement in two directions. If an arm is used on a shaft, the outer end of the arm will have a significant displacement in the third direction when the arm length is equal to, or greater than, the distance between the bearings.

The errors in each of three directions are next added. If a complicated mechanism is involved, it may be desirable to use subtotals to separate phases or specific components. This procedure is helpful in determining which part of the mechanism contributes the greatest error. Then, if modifications are introduced to reduce certain errors, it will not be necessary to repeat the other parts of the computation.

Average error is determined by calculating the root mean square (rms) value of the individual deviations:

$$\text{rms} = \sqrt{\frac{A^2 + B^2 + C^2 + D^2 \ldots . N^2}{n}}$$

where $A, B, C, D, \ldots, N$ = individual deviations, and n = total number of deviations.

When subtotals are used, the rms error is calculated for each group. Then, the rms total error is again computed, and each group is treated as an individual quantity with foregoing formula. This procedure is not mathematically correct, but it is close enough for practical purposes.

Combined Errors: If the shaft of a rotating mechanism is coincident with the Z-Z axis, errors in the X-X and Y-Y directions indicate that the theoretical center of rotation is not coincident with the shaft. Under conditions of maximum error for each source, the origin of the system of axes has shifted. The magnitude of this shift is the vectorial sum of the total errors in the X-X and Y-Y directions.

Before errors in the Z-Z direction are combined, the function of the mechanism must be studied carefully. At this point, the method departs from a rigorous mathematical treatment. The true function is to be approximated by a straight line.

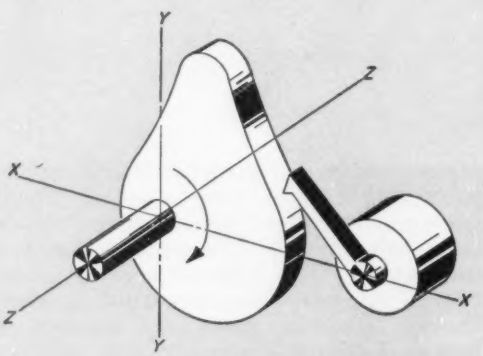
Usually this line will not pass through the end points of the curve. If a portion of the function is critical, the straight-line approximation should be made parallel to that portion. Make this approximation by laying a straight edge over the function curve. Then, move it until the area above the line

Example 1—Simplified System Analysis

A pitch-manuever mechanism is to be used to change the attitude of a missile from vertical at the moment of launch to the position required on the course. The desired program is presented as a disc-type cam. A point on an arm will trace the cam profile. The arm is attached to the shaft of a precision potentiometer. Assume that the cam contour is theoretically perfect, the starting point is perfect, and the cam rotates uniformly at the correct speed. Since this is a two-dimensional cam, it will involve errors in the X-X and Y-Y directions only.

A study of this apparatus reveals six sources of error which can affect the accuracy. These errors are tabulated and arbitrary values assigned for illustrative purposes.

The size of the cam and the length of the arm are critical dimensions. Consequently, suitable dimensions must be assumed. Since this cam is the biggest part in the apparatus, its size will determine the size of the mechanism. Even though a large cam is desirable for accuracy, assume the cam limited to a maximum radius of 2 in. The minimum radius is assumed to be 0.5 in., giving an effective rise of 1.5 in.



Simplified pitch-program device.

Error Analysis

Source of Error	Magnitude (in.) X-X	Y-Y
Length of tracer arm	0.002	0.002
Eccentricity of bearings		
Inner race	0.0001	0.0001
Outer race	0.0001	0.0001
Surface irregularity	0.0001	0.0001
Center distance	0.001	*
Zero setting of potentiometer	0.001	0.001
Linearity of potentiometer (0.15%)	0.001	0.001
Resolution of potentiometer (0.05%)	0.0007	0.0007
Total deviation	0.006	0.005
rms deviation	0.0028	0.0026

Total combined deviation	0.0077 in.
Total system error†	0.51%
rms combined deviation	0.0036 in.
rms system error	0.24%

*There is no error in the Y-Y direction since such error is eliminated in the zero setting.
†The system error-maximum is: [0.007 (100)]/1.5 = 0.51%.

Example 2—Spherical-Cam System

The analog data are previously stored on a hemispherically shaped cam capable of storing 500 discrete programs, Fig. A.

Any specific contour is presented, using the automatic position-seeking mechanism which rotates the cam about a vertical axis. The transducer is carried on a semicircular arm rotating about the center of the sphere. The tracer point follows an element of the basic sphere. The starting position error of the arm carrying the transducer will be minimized by a positive zero position formed by a lip around the base of the hemisphere. During the recycling operation, the tracer point is driven backward until it is stopped by this lip. The arm transporting the transducer is driven by a synchronous motor operating on precise frenquency-controlled power. Errors due to motor speed are considered insignificant.

The mechanism will be analyzed using coordinate axes X-X, Y-Y, and Z-Z with the hemispherical cam rotating about the Z-Z axis. The semicircular arm carrying the transducer rotates about the X-X axis and the transducer arm rotates in Y-Z plane. The exact contour of the cam is unknown except that it is continuous without reversal of slope.

A study of this system suggests several places where errors are unavoidable. The master cam will involve errors in contour and position. Rotation about the Z-Z axis and selection of a specific contour will involve further errors. Production cams will be made from a master cam, producing a double error.

Location of the zero point on the cam and the zero point on the contour-selection potentiometer must be co-ordinated. The zero point on the cam will be a scribe line on the lip of the cam. A low-power microscope will be used to align the tracer point with this scribe line and the electrical zero of the selection potentiometer.

Before an analysis can be made, critical dimensions must be established. The maximum cam radius of 3 in. will be the starting point of the tracer. The maximum cam fall is 1.5 in.

Compromise is involved in estimating the position error due to the sensitivity of the contour-seeking mechanism. If the mechanical system is tight, it will produce excess friction, requiring an amplifier of high gain in the servo loop. Such

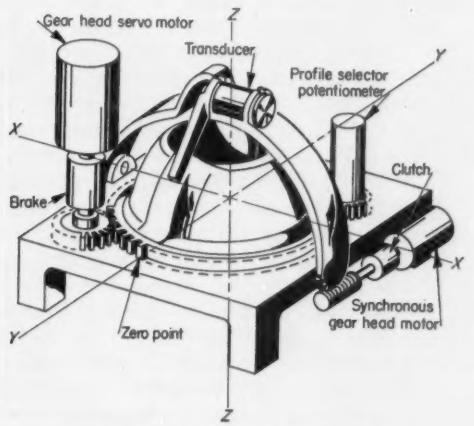


Fig. A.—Spherical cam system.

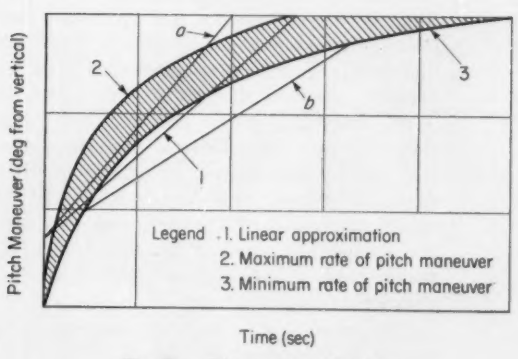


Fig. B. — Linear approximation of function to be generated.

Spherical-Cam System Error Analysis

Source of Error	Magnitude (in.) X-X	Y-Y	Z-Z
Errors in master cam			
Cam contour	....	0.001	0.001
Zero point	0.001	0	0
Position of starting lip	....	0	0.001
Errors in production cams			
Cam contour	....	0.001	0.001
Zero point setting	0.001	0	0
Position of starting lip	....	....	0.001
Eccentricity about Z-Z axis	0.0002	0.0002	0
Errors in transducer support			
Errors in location of X-X axis	....	0.001	0.001
Zero setting of tracer point	0.0005	....	....
Sensitivity of contour seeking mechanism	0.015	....	....
Errors in transducer			
End play in pot shaft	0.0007	....	....
Radial looseness (shaft bearings)	....	0.0005	0.0005
Eccentricity in shaft	....	0.0002	0.0002
Zero setting	....	0.001	0.001
Linearity of pot	....	0.0007	0.0007
Resolution of pot	....	0.001	0.001
Total deviation	0.0184	0.0066	0.0084
rms deviation	0.0062	0.0008	0.0009

Vectorial sum of X-X and Y-Y total deviations	0.0195 in.
Total Z-Z deviation × slope (0.305)	0.0025 in.
Total system deviation	0.022 in.
Total system error	1.47%
Vectorial sum of X-X and Y-Y rms deviations	0.0063 in.
Z-Z rms deviations × slope (0.305)	0.0003 in.
Total system rms deviation	0.0066 in.
Total system rms error	0.44%

Example 2—Continued

systems tend to be unstable. With a reasonable amount of friction there may be slight backlash which decreases the sensitivity.

The source and direction of the errors, along with assigned magnitudes, are shown in the table. The following facts must be considered:

1. The tracer arm travels in the *Y-Z* plane.
2. The actual error in cam contour, position, and reading is the shortest distance between the actual point and the theoretical point. The algebraic sum equals the square root of the sum of the squares of the errors about the *X-X* and *Y-Y* axes.
3. Before the *Z-Z* errors can be combined with the sum of *X-X* and *Y-Y* errors the approximate slope of the function must be determined.

Approximate Slope: A plot of the function to be generated by these mechanisms is shown in Fig. B. (Actually this function represents many families of curves lying between the limits of curves 2 and 3.) Approximations for the maximum rate of pitch maneuver and the minimum rate are made first. A straight edge is laid over the curve and moved around until the area above the curve approximately equals the sum of the areas under the curve. Then lines *a* and *b* are drawn. The linear approximation is then drawn with a slope midway between *a* and *b*.

The linear approximation gives the mean rate of pitch maneuver in deg per sec. Next, convert this slope to a cam of the desired dimensions. The cam fall is 1.5 in. The cam length is one quarter of the periphery of a 10 in. diameter sphere minus the unused portion, or about 7 in. These dimensions are graphically shown in Fig. C and the linear approximation is drawn parallel to curve 1 from Fig. B. A construction line through the origin intercepts the 4 in. length at 1.22 in. fall. Therefore, the slope is $1.22/4 = 0.305$.

The per cent of error is readily computed by dividing the total or rms error by the traverse (cam fall = 1.5 in.) and multiplying by 100.

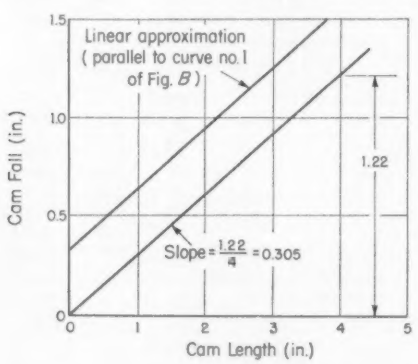


Fig. C—Calculation of slope.

is equal to the sum of the two areas below the line.

It is possible that the function involved may introduce drastic changes in the slope of the linear approximation. In that case, the calculations should be repeated for the minimum, average, and maximum slope. This process may reveal that the error

The analog data is stored on a cylindrical cam capable of storing 100 discrete programs, Fig. A. The cam surface is continuous. Any specific contour is selected by the automatic position-seeking mechanism which positions the transducer at the desired program. The starting point of the cam is located with a positive latch having no backlash. The cam is rotated by a synchronous motor operating on power of precise frequency. Therefore, errors due to motor speed are considered insignificant. The length of the effective contour will vary for different trajectories but in no case will it exceed 300 deg. The remaining 60 deg will be used to return the tracer point to the starting position so that the system can recycle.

Two systems of co-ordinate axes will be used in this analysis. The cylindrical cam will rotate about the Z-Z axis of the first system consisting of *X, Y, Z* axes. The transducer will rotate about the *Z'-Z'* axis of an independent system consisting of *X', Y', Z'* axes. The distance between the two origins, measured in the Z-Z direction, will be selected by the position-seeking mechanism.

A study of this mechanism suggests a large error resulting from the co-ordination between the origins of the two co-ordinate systems. Consequently, special provision must be made for adjusting the longitudinal relationship between the cam and the tracer point in the Z-Z direction. One solution consists of using a low-power microscope to measure the distance from the tracer point to a reference surface machined into the cam. The error due to lack of parallelness between the Z-Z and *Z'-Z'* axes is considered insignificant. Based on the overall size of the apparatus, assumed dimensions are: Cam length, 5 in.; maximum radius of cam, 2 in.; and cam rise, 1.25 in. The shortest possible tracer arm will produce the greatest sensitivity in the transducer. However, arm length is limited by the maximum radius of the cam plus the radius of the transducer. Assume an arm length of 2.75 which, with a cam rise of 1.25 in., produces an angular traverse of 32 deg.

The calculation of slope for the cylindrical cam system is illustrated in Fig. B. The method is the same as for the spherical cam system. The

is large under certain conditions. Thus, the accuracy of the mechanism is not uniform over its entire range.

The mathematical slope of the linear approximation is the tangent of the inclination of the line. However, the slope as expressed in mathematical parameters is not to be used in these calculations. Instead the slope is expressed in terms of mechanical traverse and the units are expressed in inches. Assuming that the mechanism involves a three-dimensional cylindrical cam with a rise of 1.5 in. in a length of 5 in., the slope through the end points

Example 3—Cylindrical-Cam System

slope is 0.42. Therefore, the values for error in the Z-Z direction are multiplied by 0.42.

The source and direction of the errors along with the assigned magnitudes are tabulated.

Cylindrical Cam System Error Analysis

Source of Error	Magnitude (in.) X-X	Y-Y	Z-Z
Errors in co-ordinate system X, Y, Z			
Errors in master cam			
Cam contour	0.001	0.001	0.001
Longitudinal reference point	....	....	0.001
Latch or starting position	0.0005	0.0005	....
Errors in production cam			
Cam contour	0.001	0.001	0.001
Longitudinal reference point	....	....	0.001
Latch or starting postion	0.0005	0.0005	....
Eccentricity about Z-Z axis	0.0002	0.0002	....
Total deviation	0.0032	0.0032	0.004
rms deviation	0.0007	0.0007	0.001
Errors in co-ordinate system X', Y', Z'			
End play in potentiometer shaft	....	....	0.0007
Radial looseness in bearings	0.0005	0.0005	....
Eccentricity in potentiometer shaft‡	0.0002	0.0002	0.0002
Zero setting	0.001	0.001	....
Transducer errors—electrical			
Resolution	0.0007	0.0007	....
Linearity	0.002	0.002	....
Total deviation	0.0044	0.0044	0.0009
rms deviation	0.0011	0.0011	0.0005
Errors in locating the origins of two axis system			
Zero position of position seeking potentiometer	....	....	0.001
Linearity of position seeking potentiometer (0.1 per cent)	....	....	0.005
Resolution of position seeking potentiometer (0.025 per cent)	....	....	0.001
Sensitivity of position-seeking mechanism	....	....	0.015
Total deviation	....	....	0.022
rms deviation	....	....	0.008
Summation of co-ordinate errors			
Total deviation	0.0076	0.0076	0.0269
rms deviation	0.0009	0.0009	0.0051

Vectorial sum of X-X and Y-Y total deviations	0.0107 in.
Z-Z total deviation × slope (0.42)	0.0113 in.
Total system deviation	0.022 in.
Total system errors	1.47%
Vectorial sum of X-X and Y-Y rms deviations	0.0013 in.
Z-Z rms deviation × slope (0.42)	0.0021 in.
Total system rms deviation	0.0034 in.
Total system rms error	0.22%

‡The distance between the bearings of the potentiometer shaft is less than the arm length. Therefore, the tracer point has an appreciable movement in the Z-Z direction.

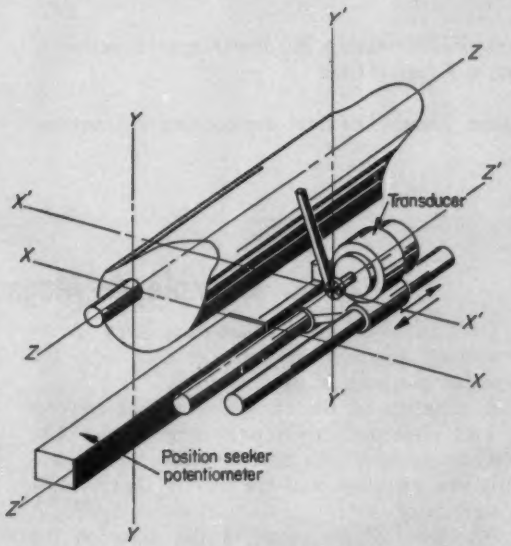


Fig. A.—Cylindrical cam system.

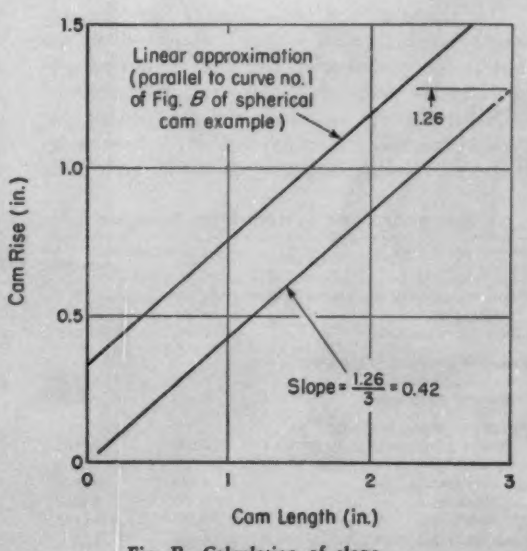


Fig. B—Calculation of slope.

is 1.5/5.0 = 0.3. If the linear approximation does not pass through the end points of the function, then the slope must be adjusted. When the ordinates and abscissas on the curve of this function are expressed in inches instead of the regular mathematical parameters, the slope can be readily determined. The process of determining the linear approximation is shown in *Spherical Cam*.

Table 1—Comparison of System Errors

System	Maximum Error (%)	rms Error (%)
Spherical cam	1.47	0.44
Cylindrical cam	1.47	0.22
Magnetic tape	1.03	0.26

System Error: The final step consists of determining the magnitude of the errors in terms of the output of the mechanism. Output is defined as the total effective travel of the mechanism, in inches.

The system error is expressed as a percentage of the total effective traverse. That is,

$$\text{Maximum system error} = \frac{\text{Combined maximum error}}{\text{Effective traverse}} \times 100$$

or

$$\text{rms system error} = \frac{\text{Combined rms error}}{\text{Effective traverse}} \times 100$$

Summary: The error calculations for the three mechanisms for controlling pitch maneuver are compared in Table 1. These computations indicate that the magnetic tape system is superior in system accuracy.

Example 4—Magnetic-Tape System

Data are stored in timebase-pulse form. A reproducing amplifier recovers the data from the tape for playback in original form.

A variation of the three-dimensional analysis is used since the predominate error is time. The mechanical deviations produce errors which have only one direction and are readily converted to a time error.

All errors of placement of the pulse on the tape are repetitive. The same deviation will exist for both the recording and playback of a program. The tape is endless. The program always starts from the same point. The starting position error is estimated at 0.001 sec.

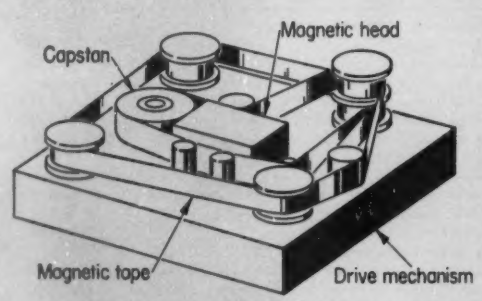
The shape of the pulse front affects the apparent accuracy with which it is placed on the tape or reproduced from the tape. Improved performance is obtained if the pulse is modulated with a frequency in which the duration of one cycle is insignificant in relation to the time error. If the modulating frequency is 10,000 cycles, the maximum error resulting from pulse shape becomes 0.0001 sec. The maximum error resulting from both recording and playback therefore is 0.0002 sec, which is insignificant.

It is not necessary that the power source be exactly 400 cycles, if the same power source is used for both the recording and playback operations. A time error will occur only when there is a drift in the frequency between the two operations.

The digital-to-analog converter consists of a stepping motor and a potentiometer with suitable gearing between the two. The motor makes 30 deg steps. The single-step gearing has a large ratio. Consequently all gear errors including back-lash, are considered insignificant. The potentiometer has the usual errors of zero setting, linearity, and resolution. The master programs are recorded on perforated tape. The errors are expressed in seconds of elapsed time and per cent of the mean time of the pitch program, which is 60 sec. The summary of the errors in this magnetic tape system is shown.

Magnetic Tape System Error Analysis

Source of Errors	Magnitude (sec)	Magnitude (per cent)
Errors in recording the master program		
Starting postion	0.001	0.0016
Starting time delay	0.005	0.0083
Errors in playback of recorded data		
Starting position	0.001	0.0016
Starting time delay	0.005	0.0083
Errors in analog converter		
Time lag in stepping motor	0.008	0.0133
Potentiometer errors		
Zero setting	0.100	0.1667
Linearity	0.400	0.6667
Resolution	0.100	0.1667
Total deviation	0.620	1.03
rms deviation	0.155	0.26



Magnetic tape system.

Thermal Stresses in Design

Part 17—Determining a Safe Working Stress

- **Brittle Materials**
- **Model-Prototype Correlation**

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PROPER design depends on thermal operating stresses which are below some level regarded safe for the material and structure involved. The question arises, then, as to what shall be the criterion for choosing the safe working stress. Obviously, the answer to this question depends on many factors—nature of the material, nature of the operation, and type and consequence of failure.

Nature of Material: Among the factors that enter under nature of material is whether it is brittle or ductile. Strictly speaking, the distinction here is arbitrary. For brittleness is not really a material property, but an interaction of material property, shape of the structure, and type of loading. A material utilized under one set of conditions can show ductility, while under other conditions it can be brittle.

Attempts to be rigorous in definition are avoided if conventional engineering concepts of brittleness are employed. A material is brittle if failure occurs in a tensile test of a smooth specimen with less than some minimum of permanent elongation, about 0 to ½ per cent. To evaluate thermal stresses for structures composed of such materials, failure can usually be assumed to be governed largely by the elastic stress distribution, and plasticity need not be considered in the computation of stresses. Ductile materials, on the other hand, may require consideration of plasticity. Type and magnitude of the errors

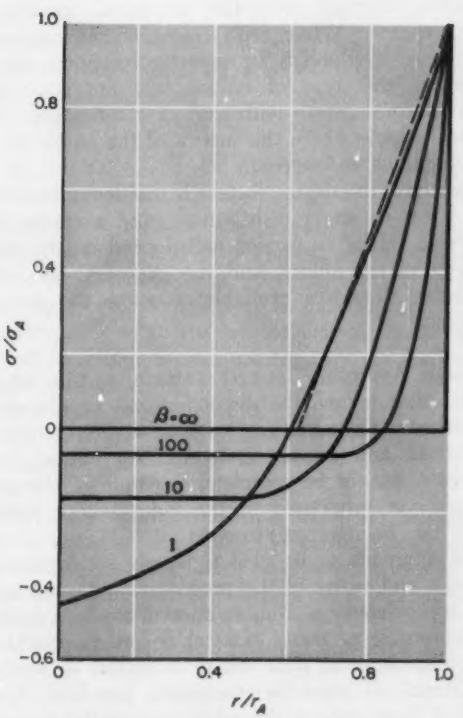

Fig. 102—Relative stress distribution at time of maximum stress in disc thermally shocked at periphery. Disc was circular, had parallel sides, and was insulated on flat faces.

that result must be ascertained when plasticity is neglected.

Nature of Operation: Of utmost importance in considering safe working stresses is the nature of the operation. Is the load applied repetitively? How long is the material at the high temperature where creep can occur, compared to the time at low temperature? Is steady load superimposed on the thermal loading? These are some of the questions which must be answered.

The same thermal strain that is safe if the inelastic portion is converted instantaneously to slip-type of plastic flow can be unsafe if the operation is sufficiently slow to permit some of the inelastic portion to be converted to creep. What may seem like a small static load can, in the presence of thermal stress, cause inordinately large deformations, destroying a clearance, or otherwise desirable geometry.

These factors are perhaps of greater importance for ductile than for brittle materials. But, even normally brittle materials can creep at high temperatures. Choice of working-stress level must, therefore, depend greatly on the manner in which the part must be operated, and other loads present.

Failure: The consequence of failure governs the working-stress level. For example, thermal-stress cracking of combustion liners of turbojet engines is common. But, such failures frequently do not immediately interfere with the continued operation of the engine. While replacement of the cracked part during overhaul is an important economic consideration, this type of failure does not rank in potential consequence with that of a component of a space vehicle where the success of the entire mission might be endangered.

Therefore, the degree to which the determination of a stress or strain distribution (and a choice of allowable values) is carried will depend on the importance of the failure, and the analytical and experimental resources available to make the determination.

Design Approach: In this article, and in the articles that follow, the discussion will be directed at methods of determining suitable working stresses for brittle and ductile materials. Obviously, the discussion cannot be complete; the state of the art has not yet progressed to the point where every aspect can be rigorously treated.

The approach to be used is largely an engineering one, and many of the procedures indicated are only approximations. But, an attempt has been made to incorporate as many rational factors as possible, using experimental data where available, to verify procedures. If must be recognized, however, that some of these procedures, while apparently reasonable, have not as yet been verified experimentally. Much remains to be done in the development of the science of design for thermal stress.

Discussion is divided on the basis of whether the material is brittle or ductile, using the loose concept already described for defining this property. For brittle materials, the discussion is limited to consideration of experimental techniques for determining a strength value. Determination is made from either a bending test or a thermal-shock test which can be expected to characterize the material under the stress distribution encountered in service. No at-

Nomenclature

- h = Height, in.
- l = Length, in.
- m = Material homogeneity
- R = Risk of rupture
- r = Radius, in.
- S = Probability of failure
- V = Volume, cu in.
- w = Width, in.
- x = Distance, in.
- β = Quench severity
- θ = Dimensionless time
- σ = Stress, psi

Subscripts

- A = Maximum radial distance
- b = Bending strength
- i = Element
- O = Material inherent strength
- t = Tensile strength
- u = Level below which no failures can be expected

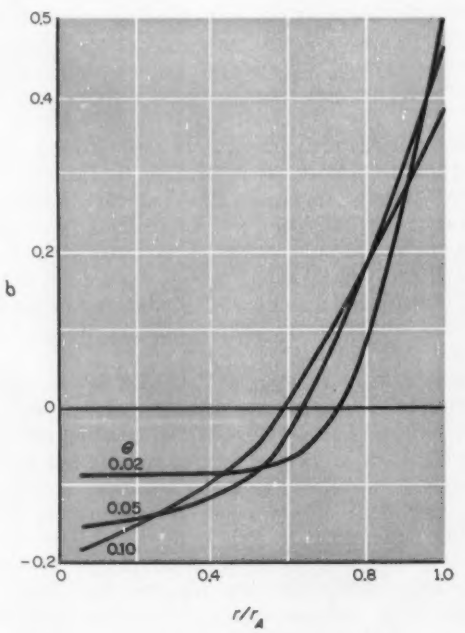

Fig. 103—Stress distribution in disc for various values of dimensionless time, with $\beta = 10$.

tempt is made to discuss the behavior of normally brittle materials in a temperature range where creep and placticity become important.

To some extent the results of the discussion for ductile materials may be applicable here. For ductile materials, plasticity theory is applied for determination of working strains, rather than the application of elastically determined values conventionally used in design. Criteria for failure in direct loading, in alternating loading, and in combinations of the two will then be considered.

Strength of Material: To determine the performance of brittle materials, whether in a thermal shock or a slowly applied thermal stress, it is important to know the strength of the material. Yet, as has already been indicated, the strength of a brittle material depends to a considerable extent on the volume of material tested, and on the stress distribution in the test part.[1] Hence, it is important to evaluate the material under the volumetric stress distribution which actually exists. This can be accomplished either by actually determining the strength of test specimens under simulated stress distribution, or by developing a theory whereby test results of convenient laboratory specimens are extrapolated to the required conditions.

▶ Risk of Rupture Criterion

When a brittle material undergoes a spectrum of stress histories, as is the case during a thermal-shock application, failure is not always likely to occur at a time when the computed stress in the most highly stressed region is a maximum. Strength depends not only on the stress but on the probability that a flaw exists in the material in the particular region of high stress. Thus, the stress may be high at one instant during thermal shock, but concentrated in a small volume of the material. At a later time, the maximum stress may be lower, but high stresses may be distributed over a larger volume.

Probability of failure may be greater in the latter case. The lower nominal stress together with the most serious flaw in the larger volume under stress represents a greater hazard toward exceeding a critical stress in a localized region than does the higher nominal stress together with its most serious flaw in the smaller volume.

To reduce the problem to quantitative terms, the relative importance of stress and volume in producing failure must be stipulated. The concept of risk of rupture R can be used:[17]

$$R = \int_V f(\sigma_i)\, dV_i \qquad (124)$$

where σ_i = stress in the element of volume dV_i, and the integral is taken over the entire volume of the part under stress.

Thus, every element of volume which is under stress contributes to the risk of rupture. However, only those elements under *tensile* stress are considered to contribute to the risk of rupture. Elements under compressive stress are neglected, partly because compression is not as detrimental in causing fracture as is tension, and partly because of mathematical complexities that arise when the compressive elements are included.

An analytical form for $f\ (\sigma_i)$ is

$$f(\sigma_i) = \left(\frac{\sigma}{\sigma_0}\right)^m \qquad (125)$$

where σ_0 = material constant relating to some inherent strength, and m = material constant relating to material homogeneity. The higher the value of m, the more homogeneous is the behavior of the material. As m approaches infinity, the material behaves as if failure were governed by the maximum-stress concept.

In a more general form for $f\ (\sigma_i)$,

$$f(\sigma_i) = \left(\frac{\sigma - \sigma_u}{\sigma_0}\right)^m \qquad (126)$$

where σ_u = stress level below which no failures are to be expected. Equation 126 permits closer correlation of analytical and experimental results, but Equation 125 will be used in this treatment for simplicity.

If Equation 125 is substituted into Equation 124,

$$R = \frac{1}{\sigma_0{}^m} \int_V \sigma^m\, dV \qquad (127)$$

Equation 127 is used mainly in the quantitative

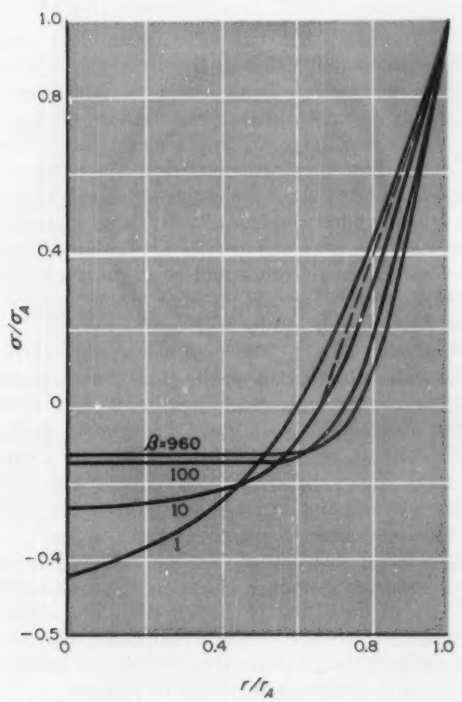

Fig. 104—Relative stress distribution in disc at time of maximum risk of rupture, $m=3$.

[1]References are tabulated at end of article.

comparison of two specimens having different volumes or stress distributions. If the risks of rupture for the two specimens are equated, relations between the maximum stresses at the conditions of rupture can be obtained.

Consider, for example, two tensile specimens having volumes V_1 and V_2. Let the stresses at failure in each of the specimens be σ_1 and σ_2, respectively. From Equation 127, the σ^m can be taken outside the integral sign because the stress is uniform. Therefore,

$$\left(\frac{1}{\sigma_0{}^m}\right)\left(\sigma_1{}^m\right)\int_{V_1} dV_1 = \left(\frac{1}{\sigma_0{}^m}\right)\left(\sigma_2{}^m\right)\int_{V_2} dV_2 \qquad (128)$$

and,

$$\left(\frac{\sigma_1}{\sigma_0}\right)^m V_1 = \left(\frac{\sigma_2}{\sigma_0}\right)^m V_2 \qquad (129)$$

or,

$$\frac{\sigma_1}{\sigma_2} = \left(\frac{V_2}{V_1}\right)^{1/m} \qquad (130)$$

Thus, the stresses at fracture are inversely proportional to the m root of the reciprocal of the volume ratio. The larger the volume, the lower is the fracture stress. This explains the commonly observed size effect.

A procedure to compare the fracture stress in pure bending with that in tension has been determined.

Let V be the volume of the tensile specimen and σ_t the tensile strength of this volume. Then, the risk of rupture at fracture is $(\sigma_t/\sigma_0)^m V$, as in the previous case. For the bending specimen let l, w, and $2h$ be the length, width, and height, respectively. If the surface bending stress at fracture is σ_b, then the stress at any distance x from the neutral axis is $(x/h)\sigma_b$. The volume dV under this stress is $lwdx$. Thus, if Equation 127 is integrated over the region of positive stress,

$$R = \frac{1}{\sigma_0{}^m}\int_V \sigma^m\, dV = \frac{1}{\sigma_0{}^m}\int_0^h \left(\frac{x}{h}\sigma_b\right)^m lw\, dx \qquad (131)$$

Or, since $V = 2lwh$,

$$R = \frac{lwh}{m+1}\left(\frac{\sigma_b}{\sigma_0}\right)^m = \frac{V}{2(m+1)}\left(\frac{\sigma_b}{\sigma_0}\right)^m \qquad (132)$$

If the risks of rupture for tensile and bending specimens are equated,

$$\frac{V}{2(m+1)}\left(\frac{\sigma_b}{\sigma_0}\right)^m = \left(\frac{\sigma_t}{\sigma_0}\right)^m V \qquad (133)$$

Thus,

$$\frac{\sigma_b}{\sigma_t} = [2(m+1)]^{1/m} \qquad (134)$$

For $m = 3$, $\sigma_b/\sigma_t = 2$, this solution agrees approximately with the experimental finding that the bending strength for some materials is twice the tensile strength. The method of equating risks of rupture at two conditions of rupture will now be used to analyze the case of thermal shock.

Application to Thermal Shock

Since the severity of a thermal-stress condition depends on the volumetric distribution of stress, a general treatment for all geometrical arrangements cannot be presented. The approach will, therefore, be illustrated by reference to a specific problem.

Suppose that a flat circular disc is heated to a uniform high temperature, and then suddenly cooled at the peripheral edge while the flat faces remain insulated. Relative stress distribution in the disc at the time of maximum stress is shown in Fig. 102. The abscissa is the ratio of radius r to the maximum radius of disc r_A. The ordinate is stress σ divided by stress at the rim σ_A. At the instant of maximum rim stress, the stress gradient in the vicinity of the rim depends considerably on quench severity β.[1] Hence, if the material were to be evaluated on the basis of maximum stress and stress distribution, it would be important to give special attention to the quench severity β before arriving at a suitable working stress level.

Fortunately, as illustrated in Fig. 103 for the value $\beta = 10$, the volume of material under relatively high stress is limited to the surface layers when the surface stress is a maximum. On the other hand, the volume under relatively high stress increases after the surface has passed through its maximum stress.

For this reason, the risk of rupture does not achieve its maximum value at the time the surface stress is a maximum. It occurs at a later time, when there is an optimum combination of high surface stress and large volume under stress. The actual calculation of risk of rupture can be achieved by numerical integration for assigned values of m, or by suitable approximations.[18,19] These approximations result in general formulas applicable to any value of m. Later, reference will be made to particular calculations. For the present, some general features only of the results will be discussed.

As illustrated in Fig. 104, such calculations show that the stress distribution at the time of maximum risk of rupture depends much less on β than does the stress distribution at the time of maximum stress, Fig. 102. Thus, a material evaluated under the stress distribution shown by the dotted line in Fig. 104 will give a reasonable average strength usable over a considerable range of quench severities.

Such a stress distribution can be achieved in a bending specimen having a thickness approximately 65 per cent of the radius of the test disc. The region of compression is not properly simulated, but as previously indicated, compressive regions are usually neglected in considerations of risk of rupture.

To properly simulate the volume and surface area, the test bar should have a width equal to the axial

thickness of the disc, and it should be tested in bending under symmetrical four-point loading The length between the inner supports is at a constant for the bending moment and should be equal to the perimeter of the disc.

Calculations in Fig. 104 are for $m = 3$, which is a fairly extreme case. For more homogeneous materials having larger values of m, the most severe condition tends to occur more closely to the time when the surface stress is a maximum, Fig. 102. Use of a test specimen for strength evaluation as previously described is shown by the dotted line, Fig. 102.

Obviously, the high values of β would not be properly simulated. But, the more homogeneous the material, the less is the need to simulate the exact stress distribution, and the more significant the maximum stress becomes. Hence, the maximum stress may be sufficiently accurate for design purposes even though determined under inexact stress distribution.

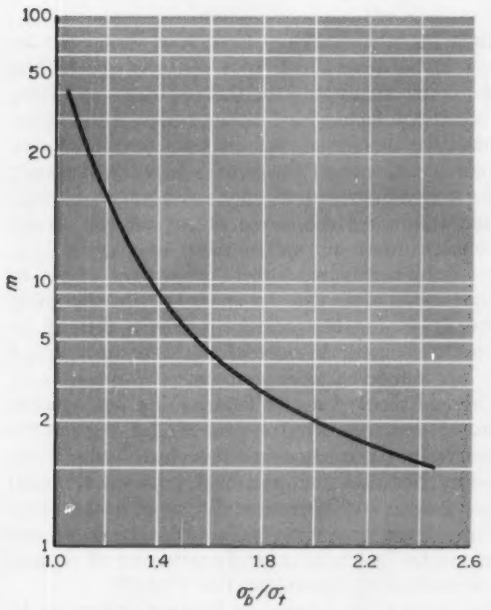

Fig. 105—Plot for determining homogeneity factor m from measured values of tensile and bending strength.

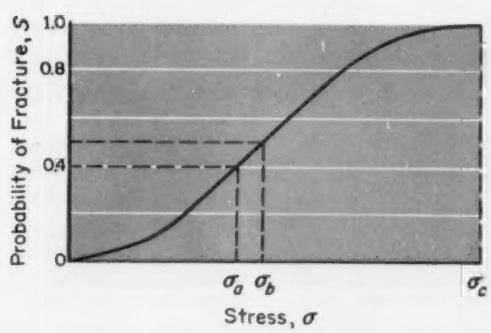

Fig. 106—Probability of fracture as a function of stress.

Homogeneity Factor

As previously indicated, preliminary design may proceed by assuming a reasonably low value of m, about 3. Stress distribution is determined from an elastic-stress analysis, using a reasonable estimate of heat transfer coefficient β. Stress distribution and the volume and surface under stress are then simulated in a suitable test specimen, and the strength is measured. This strength becomes the working stress. For more precise design, it is desirable to determine m directly for the material to be used. Several approaches are possible.

Combination of Tensile and Bending Tests: As shown in Equation 134, the ratio of bending to tensile strength for two specimens having the same volume depends only on m. Hence, the experimental determination of this ratio, together with the plot of Equation 134, Fig. 105, permits direct determination of m.

However, two complications must be recognized. First is the difficulty of applying a pure tensile load to a brittle material. Concentricity of load becomes of utmost importance. By the use of special concentric loading fixtures, some of the error due to load eccentricity may be reduced.[20] But, this is at best a difficult problem.

The second complication is the need for many duplicate tests. The very nature of the problem dictates the need for many repetitive determinations of both tensile and bending strength, and the median values used in conjunction with Equation 134.

Strengths Over a Range of Volumes: If a series of tensile or bending tests are conducted on specimens over a range of volumes, the value of $1/m$ can be determined as the slope of a logarithmic plot of stress ratio against volume ratio with Equation 130. Again, however, many duplicate tests must be conducted to obtain median values. A further complication arises because, as the volume is changed, the ratio of surface-to-volume usually changes. Since the relative sensitivity of materials to surface and volume flaws is not known, interpretation of the results becomes difficult.

Statistical Evaluation of Replicate Tests: Since the two previous methods involve experimentation on replicate specimens from which only the median results are used, it appears desirable to develop methods of analysis which make greater use of these replicate tests. Fig. 106 shows one such approach that can be used for any type of replicate test data. However, reference will be made to bending tests because they can be performed with minimum scatter introduced by the test procedure itself. Proportions of the specimen should be chosen to duplicate as closely as possible the computed stress distribution

at the time of maximum risk of rupture. They should also duplicate the volume of material under stress.

The ordinate in Fig. 106 is the probability of fracture at a given stress. Experimentally, this probability is determined by noting the percentage of tests in which failure occured at stress levels below the chosen value of the abscissa. The relationship between probability of failure S and risk of rupture R defined in Equation 124 is[17]

$$R = -\log_e (1 - S) = \int_V f(\sigma_i)\, dV_i \qquad (135)$$

If Equation 132 is applied for the case of bending,

$$R = -\log_e (1 - S) = \log \frac{1}{1 - S}$$

$$= \frac{V}{2(m + 1)} \left(\frac{\sigma_b}{\sigma_0} \right)^m \qquad (136)$$

Thus, if S is experimentally determined as a function of σ_b, the value of m can be obtained from

$$\log (\log_e) \left(\frac{1}{1 - S} \right) = m \log \sigma_b +$$

$$\left[\log \frac{V}{2(m + 1)} - m \log \sigma_0 \right] \qquad (137)$$

Hence, a plot of $\log \log_e 1/(1\text{-}S)$ versus $\log \sigma_b$ should give a straight line of slope m. The value of σ_0 can be determined from the intercept of this line (given by the expression in brackets in Equation 137), together with knowledge of volume V and value of m determined from the slope of the line.

Table 1—Summary of Steatite Bending Tests

Specimen Number (Testing order)	Failure Stress (psi)	Probability of Failure, S
7	14,300	0.042
10	15,000	0.125
5	15,400	0.208
9	16,100	0.292
4	16,600	0.416
11	16,600	0.416
3	16,700	0.583
6	16,700	0.583
12	16,900	0.708
1	17,000	0.792
8	17,600	0.875
2	19,600	0.959

An example of the statistical approach toward determining homogeneity factor m uses ceramic steatite.[18] Table 1 shows the arrangement of the data for determining the failure probability S. Fig. 107 provides the necessary plot for determining m and Fig. 108 shows the excellent correlation between the experimentally determined fracture-probability curve and that derived from Equation 135.

The advantage of the statistical approach is that it provides the numerical values of m and σ_0. It also involves multiple testing of specimens under stress distributions closely simulating those to be encountered in the thermal shock under investigation. Direct-strength determination and knowledge of the degree of duplicability to be expected are important types of information that add confidence to the predicted performance of the final design.

Working Stresses from Shock Tests

Thus far, the working-stress level has been assumed to be determined by a series of mechanical tests suitably simulating the thermal-stress condition. Homogeneity factors and other material properties necessary to extrapolate results from one set of conditions to others were also based on mechanical tests. A few thermal-stress tests conducted under carefully chosen conditions can serve as an adjunct to the mechanical tests, or replace them completely.

An important advantage of a thermal-stress test is that evaluation can be made at the necessary temperatures and temperature gradients thereby introducing the proper material property variations if they are temperature-dependent.

Thermal-shock tests for determining homogeneity factor m and the effective strength for a given size of specimen have been described previously.[21] For the quenched disc, thermal-shock tests are necessary under at least two known conditions of heat-transfer coefficient. If homogeneity factor m is determined from mechanical tests, a single condition of thermal shock suffices to determine the strength.

For steatite, the agreement between properties determined from mechanical tests and thermal-shock tests was remarkably good.[21] These tests involved a material of extremely high homogeneity. Hence, the scatter in the thermal-shock data as well as in the determination of other material properties was very low. However, the uncertainty regarding a

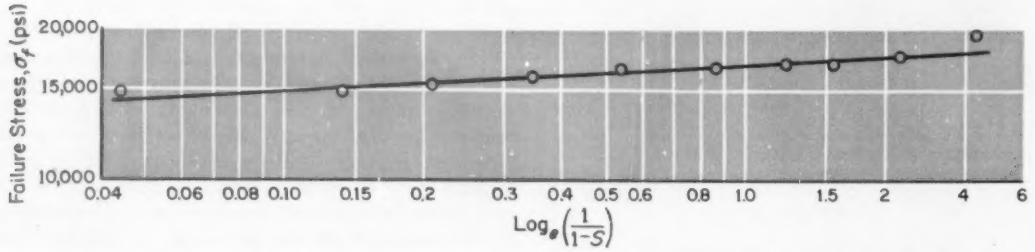

Fig. 107—Curve for determining m from experimental fracture data of steatite bars in bending tests.

working-stress level resides largely in materials having low values of m.

Scatter in the data is thus expected to be an inherent property in such materials. This makes replicate thermal-shock tests necessary for statistical analysis, or at least for the determination of a representative median, and minimum strength values. For critical designs, where failure cannot be tolerated, the minimum properties must be used in design calculations.

Heating Versus Cooling

When the service part is cooled on the surface, contraction of the outer layers causes tension. Failure, when it occurs, is initiated somewhere at the surface or its near vicinity. When the part is heated, however, expansion of the surface layers causes compression which is balanced by tensile stresses in the central region. Although shear induced by the compression may cause surface spalling, the more critical type of failure occurs when a tensile crack develops in the inner region.

Data on the properties of materials subjected to center-body tension and surface compression are very fragmentary because of the difficulty of achieving such a stress distribution in mechanical loading tests. The limited data available are from thermal-shock tests of cylinders and spheres in which some uncertainties existed and in which the rate of loading was much higher for the cooled specimens.[19,22] These data showed that alumina had much higher strength in the case of heating than for cooling. Depending on the specimen size, the discrepancy in strength can be as high as a factor of 2.

Thus, if designs for tensile stress in the interior portions of a body are based on strength determinations on bending specimens, they can be expected to be conservative. This is true because the highest tensile stresses of bending specimens are at the surface.

Design Considerations

For brittle materials, the working-stress level should be experimentally determined from samples of material which have been satisfactorily processed. This processing should conform as closely as possible to that of the final working part. Since volume under stress and stress distribution within the volume govern, to some extent, the stress level that can be supported, these factors should also be simulated.

Obviously, it is not possible to reproduce in the test piece all the pertinent variables in the final part. Hence some method of correlating part behavior and laboratory specimen strength is very useful.

The statistical approach which postulates the existence of an inherent strength and a homogeneity factor serves as a minimum useful initial approach. If specimens and test conditions are selected to simulate as closely as possible the conditions in the prototype, the degree of extrapolation in predicting the behavior of the prototype can be minimized. Simple bending tests provide the most useful information because they can be performed with a minimum of experimental difficulty.

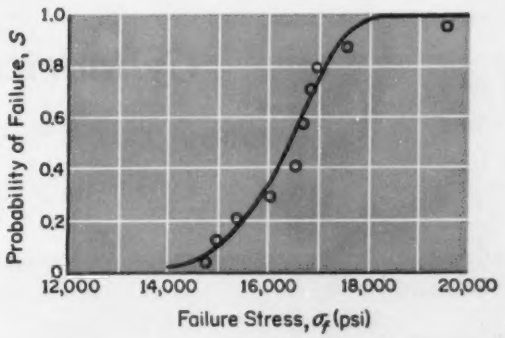

Fig. 108—Experimentally determined fracture-probability curve for steatite bars.

When a design must be undertaken without the benefit of a preliminary test program to determine effective strength, published bending-strength data may be used. Degree of scatter in specimen test results is extremely useful. At the least, it is an indication of scatter that can be expected in the prototype. If used more sophisticatedly, it can provide information about the homogeneity factor which is useful in more quantitative predictions of prototype behavior.

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This article is the seventeenth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of Machine Design in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" .. June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" . August 7, 1958
4. "Causes of Fatigue in Ductile Materials" ..... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959
7. "Exact and Approximate Solutions" ..... February 5, 1959
8. "Elastic Stresses by Energy Methods" ..... February 19, 1959
9. "Elastic Stress Solutions" ..... March 5, 1959
10. "Elastic Stresses by Minimizing Residuals" .... March 19, 1959
11. "Stresses Under Plastic Flow and Creep" ..... July 9, 1959
12. "Plastic Stresses and Strains by Successive Approximations" ..... July 23, 1959
13. "Incremental Solutions for Plastic Stresses and Strains" ..... August 6, 1959
14. "Strain Gage Measurements" ..... October 29, 1959
15. "Strain Gage Applications" ..... November 12, 1959
16. "Measurements by Photelasticity" ..... November 26, 1959

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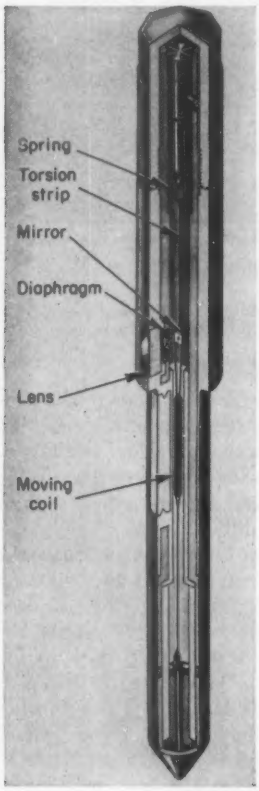
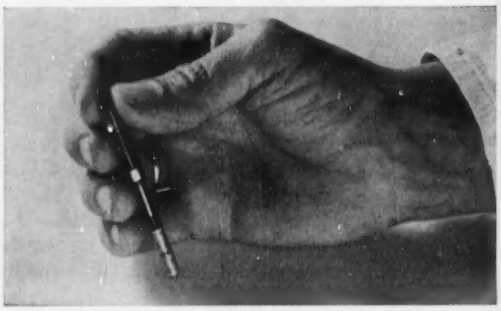
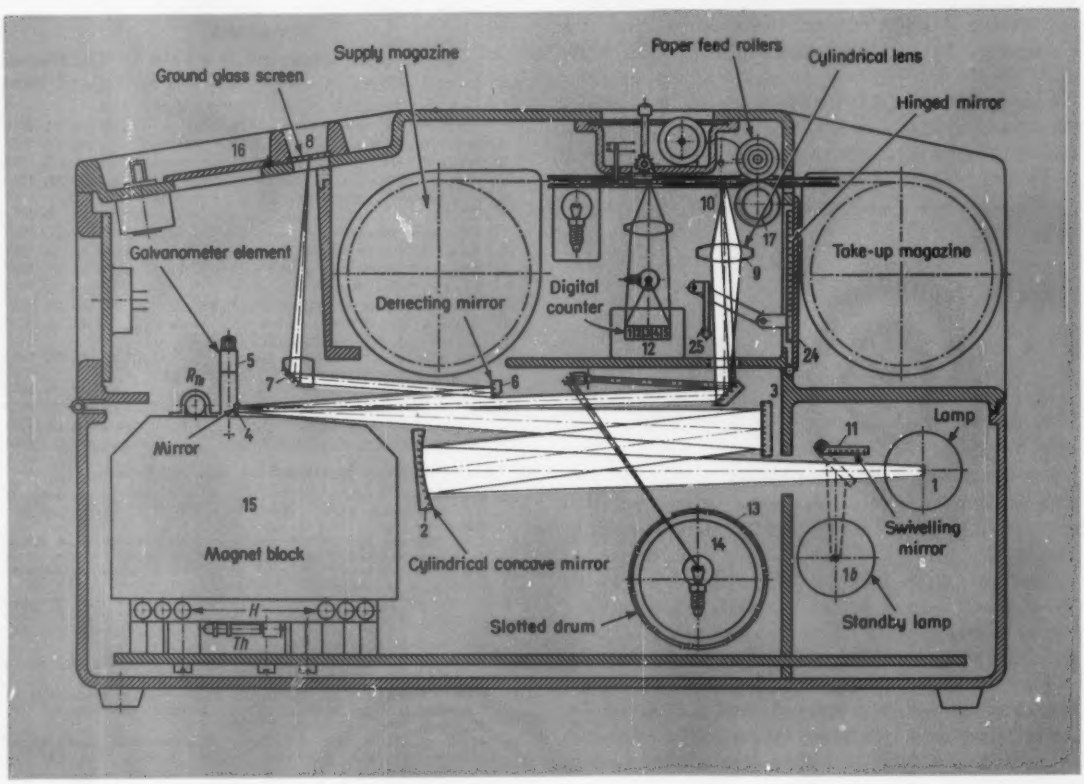


Cylindrical Lenses
and Plug-in Galvanometers

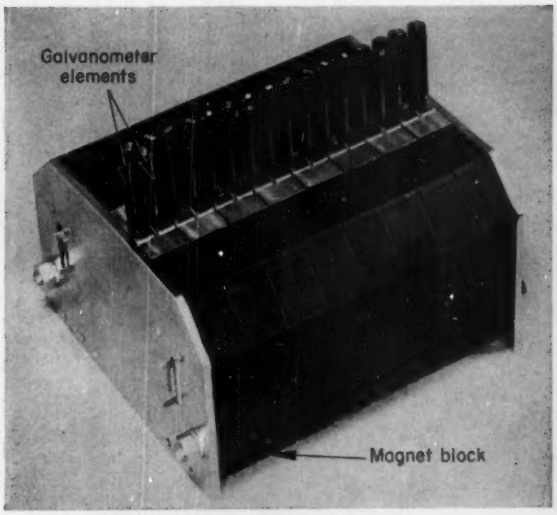
INPUT FROM AN EVENT causes a small galvanometer element to flash a heliograph-like signal to be recorded on photosensitive paper. Mirror for the unit is mounted on a torsion strip. Special iron-free material is used for the moving coil of the galvanometer because of the high induction field.



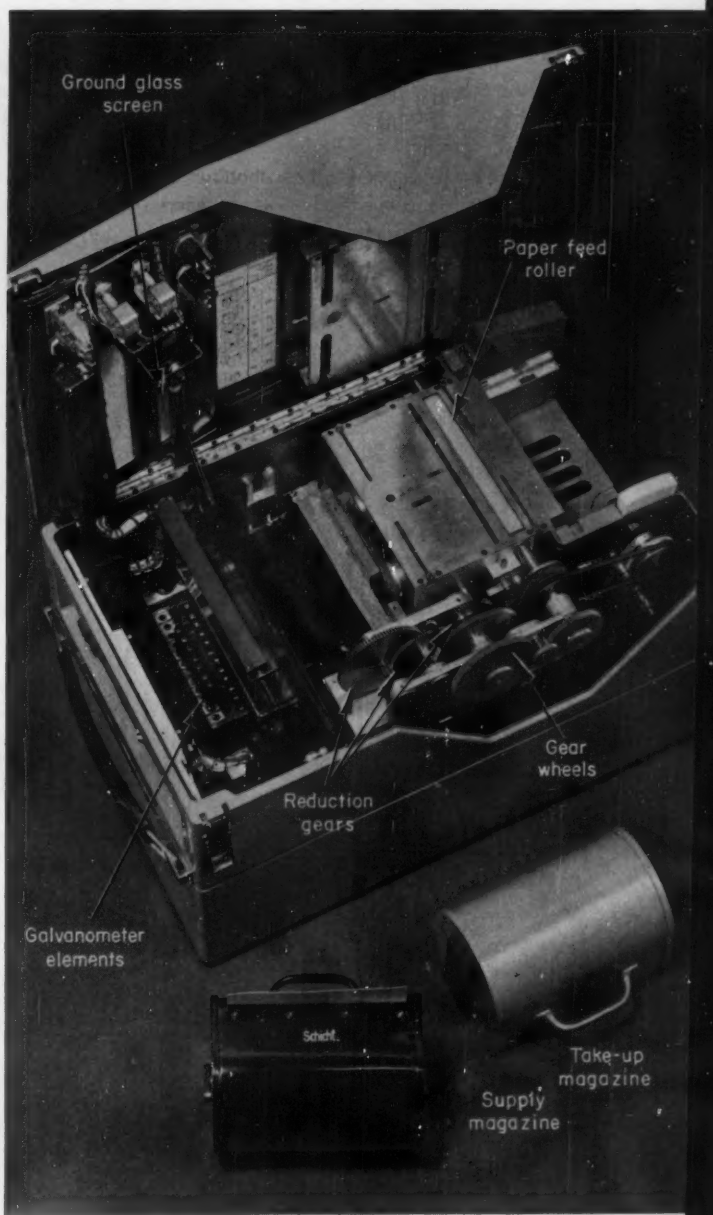
STANDBY LAMP INSURES against loss of information if the main lamp fails during a nonrepeatable sequence of events. Failure of lamp permits a swivelling mirror to drop into place and deflect light from a standby lamp into the main light path. A single cylindrical lens replaces gangs of spherical lenses to focus light from all galvanometer elements used. Similarly a single cylindrical mirror directs the light to the elements. Slotted drum projects a time grid across the entire width of the paper. Digital display is projected on the paper by an auxiliary photo system.



Simplify Design of Slow-Rate Photo Recorder



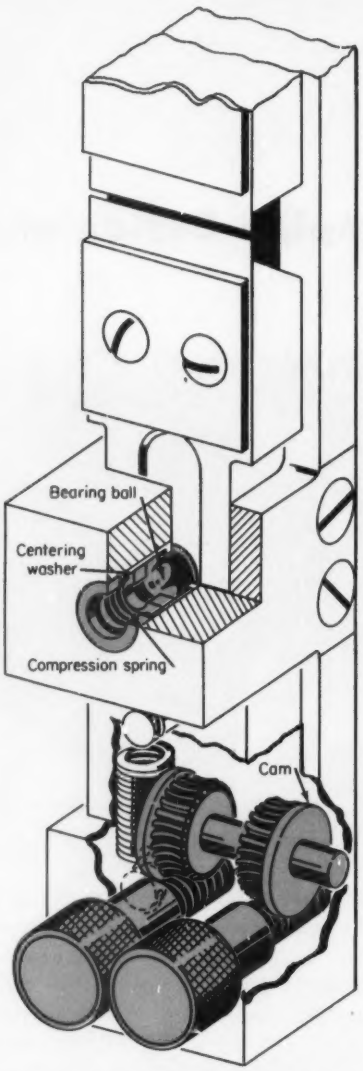
MAGNET BLOCK ACCOMMODATES up to 16 galvanometer elements to make possible the recording of that many events in a single optical system. Galvanometer elements are inserted in mounting holes in the single magnet block from above. They are turned in their sets to orient with the direction of the light beam. Oscillograph can remain closed while galvanometer elements are adjusted.

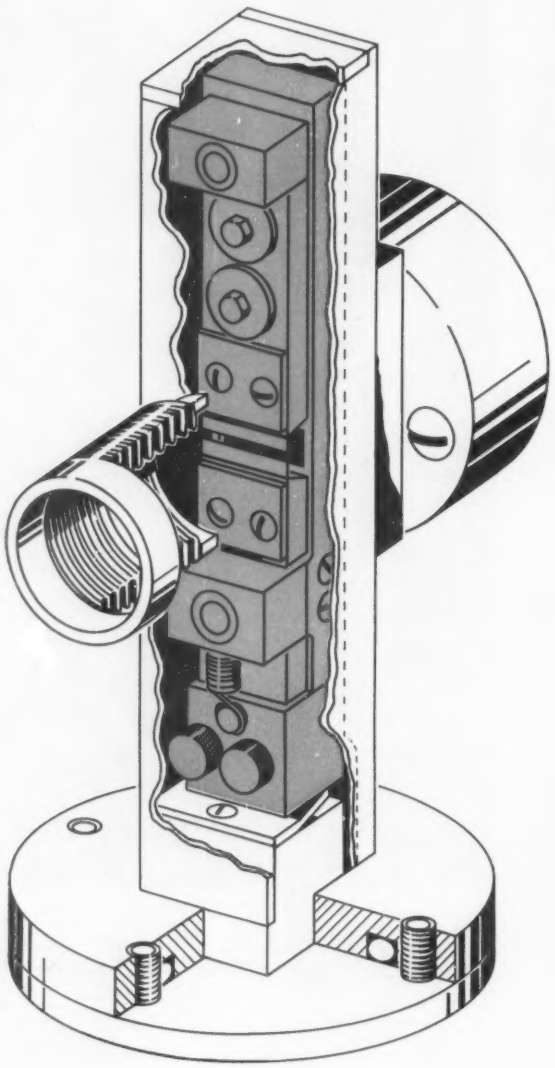


BUILDING-BLOCK DESIGN allows components to be removed or replaced. Gear wheels give six different ratios, and reduction gear train offers an optional 1:100 reduction, making a total of twelve speeds available for the paper drive ranging from 0.015 to 55 ips. Oscillograph with galvanometer elements is a design of Siemens & Halske AG, Munich, Germany.

Slide Pivots on Bearing Ball To Align Spectrograph Slit

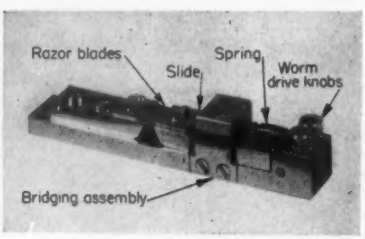
INDIVIDUAL ADJUSTMENT of two cams aligns the edges of a spectrograph slit aperture. A bearing ball forms the pivot for rotation and yet furnishes acceptably low resistance to forward and back motion. It's retained in a bridging assembly over the slide that supports one slit edge member. A nylon centering washer keeps the ball in place, and a helical compression spring presses it firmly into a longitudinal groove in the slide.



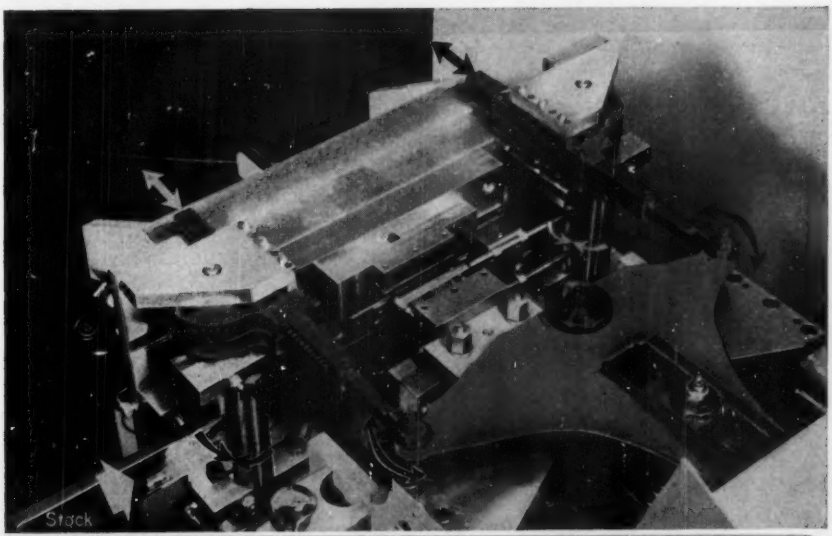


WORM-DRIVEN CAMS MAKE adjustments as fine as 0.0001 in. A fairly strong spring holds the slide in contact with the cams. One complete turn of the worm rotates the cam through 11¼ degrees. Slit edges are razor blades mounted with a slight overlap and then ground to fit.

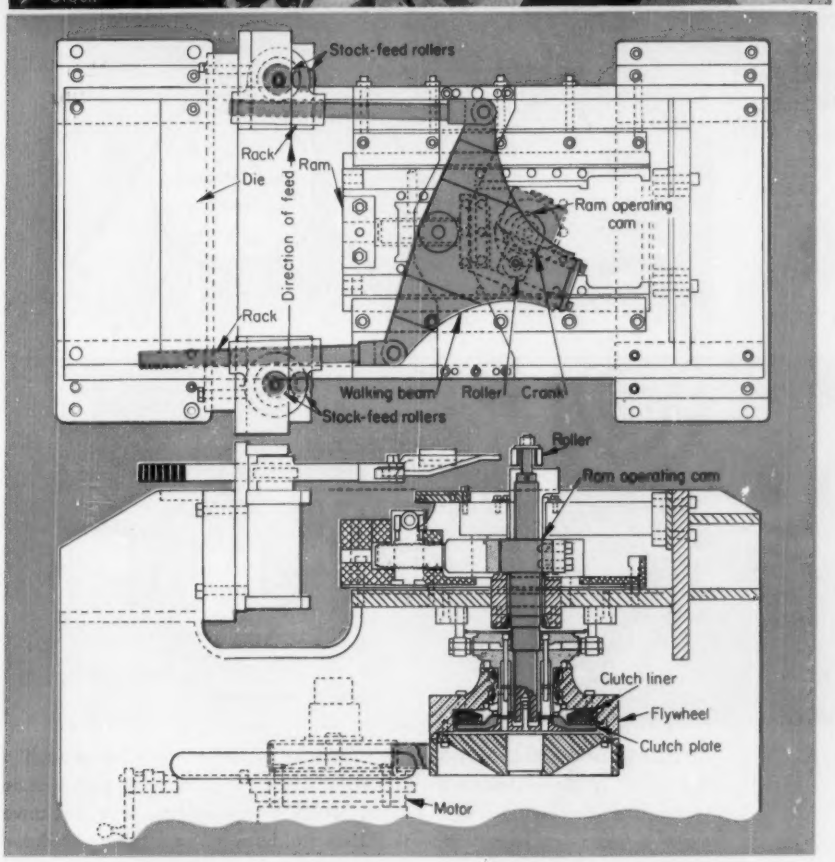
SLIT ASSEMBLY IS USED in a vacuum spectrograph for analysis of chemicals. It is reported by N. Raskhodoff of the U. S. Naval Research Laboratory, Cheverly, Md.



Walking Beam Feeds Stock In Horizontal Press



Ultrahigh-speed horizontal press was developed by Emhart Mfg. Co.'s Hudson Div., Hudson, N. Y. It will handle light-gage metals as well as nonmetallic materials.

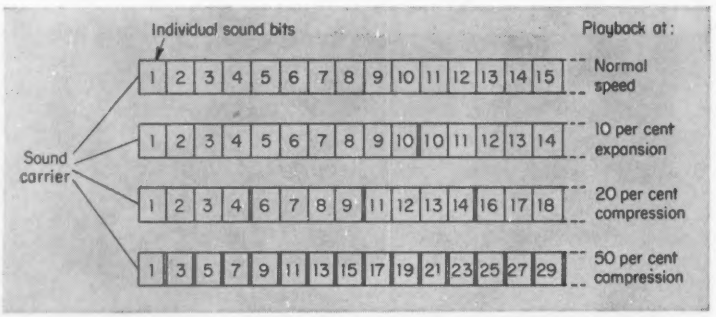


STOCK FEED TO MATCH the high operating rate of a horizontal press is achieved through a unique walking-beam linkage. Oscillating movement of the T-shaped walking beam is produced by a simple variation of the classic slider-crank mechanism. Arms of the walking beam are attached to racks which drive the stock-feed rollers. Pneumatic cylinders release roller pressure on the back stroke.

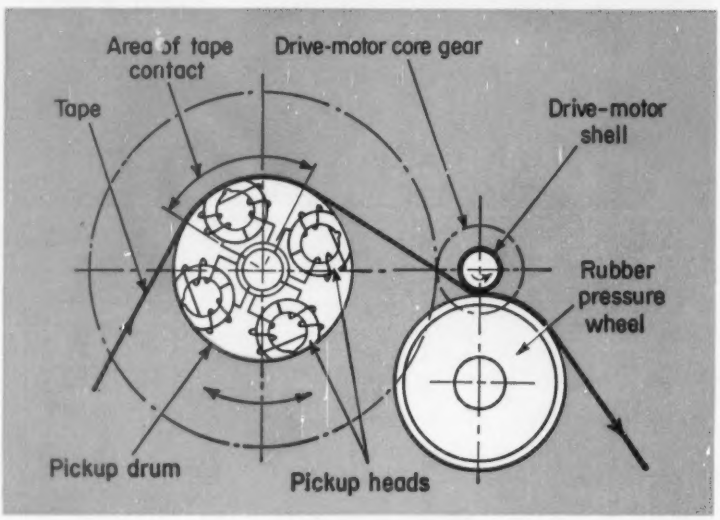
INERTIA FORCES ARE BETTER BALANCED in the horizontal setup, say designers, making possible rates as high as 1500 strokes per minute. Horizontal punch ram is eccentric-cam driven. Conventional flywheel and clutch are mounted at the base of the press. Slideways are magnesium, faced with fiber-reinforced phenolic. The same plastic is used for clutch and brake linings.

Tape Recorder Changes Playback Time Without Altering Pitch or Quality of Recording

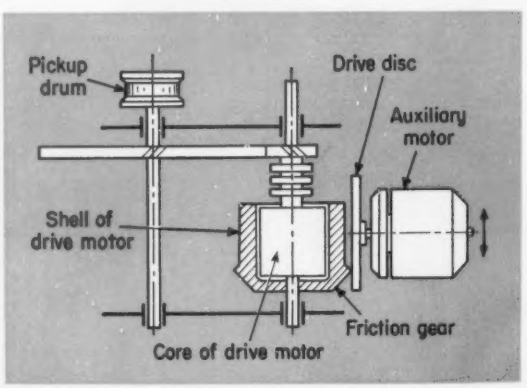
PLAYBACK TIME FOR A RECORDING is decreased or increased without changing the pitch or quality of its sound with a new tape player. To decrease playback time, bits of sound are dropped out at regular intervals. To increase time, bits are repeated at regular intervals. Of course, these bits must be shorter than the shortest discrete sound variation. Manufacturer claims playback time can be compressed to 50 per cent or stretched to 200 per cent of the original time without noticeable distortion.


Individual sound bits
Playback at:
Sound carrier
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Normal speed
1 2 3 4 5 6 7 8 9 10 10 11 12 13 14
10 per cent expansion
1 2 3 4 6 7 8 9 11 12 13 14 16 17 18
20 per cent compression
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
50 per cent compression

MULTIPLE-HEAD PICKUP DRUM drops or repeats bits by rotating with or against the tape as the heads wipe across it one at a time. Tape is wrapped 90 degrees around the drum so one head starts recording just as its predecessor leaves the tape. Pickup drum is geared to the core of the tape-drive motor, so tape speed is constant in relation to any playback head, and pitch of recorded sound does not suffer change in the playback.

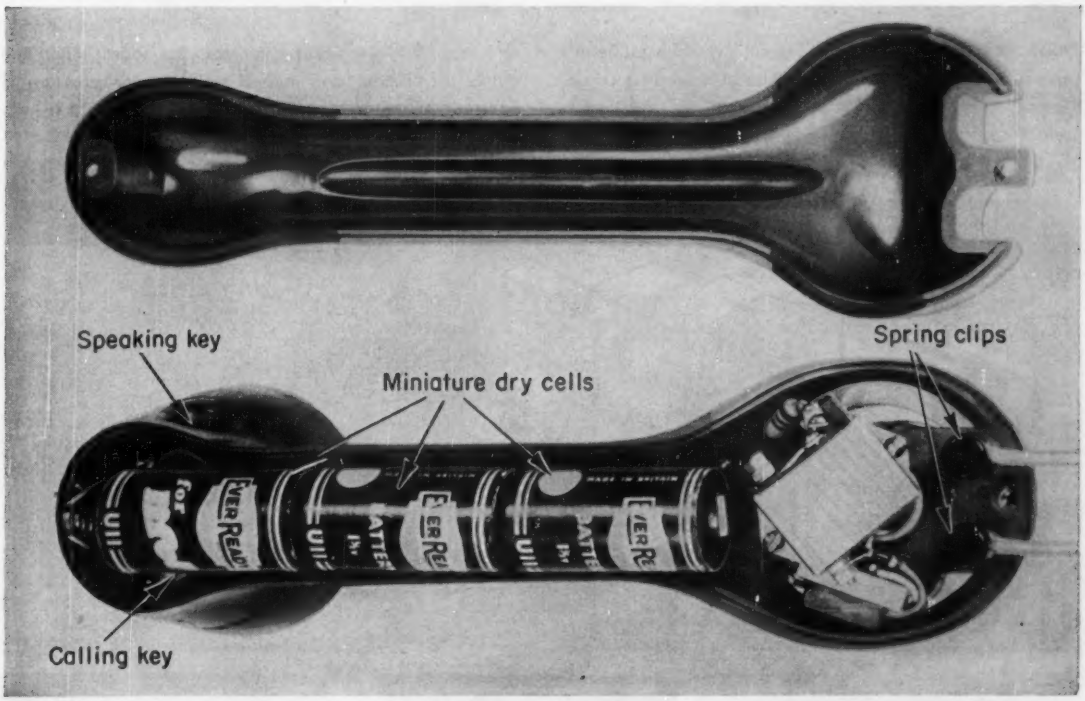


Controlled-time tape player is a product of Telefonbau und Normalzeit GmbH, Frankfurt, Germany.



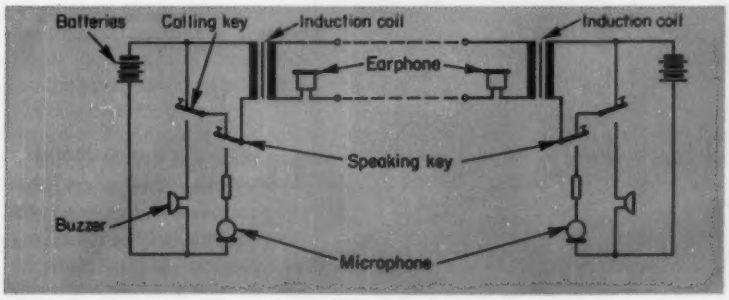
AUXILIARY MOTOR ESTABLISHES compression or expansion rate through a disc drive. Although motor shell speed is constant in relation to pickup drum speed, the disc controls the absolute speed of the system, with the drive motor acting as an electromagnetic differential between tape drive and drum.

Battery-Powered Telephone Handset Hides Small "Station" in Its Housing



HANDSET BODY INCORPORATES all necessary elements of a telephone station to complete calls over a distance of up to 9.3 miles. Induction coil, microphone, transistor and a small buzzer are neatly packed away in space usually reserved for the microphone. At the hearing end, the earphone is flanked by two pushbuttons. A red one operates the buzzer to call the other phone. A black pushbutton closes the speaker circuit; it is held down while the user is talking. In the handle, three flashlight batteries furnish 4.5 v to operate the unit. Spring-clip binding posts make possible quick installation or removal of the phone for temporary service.

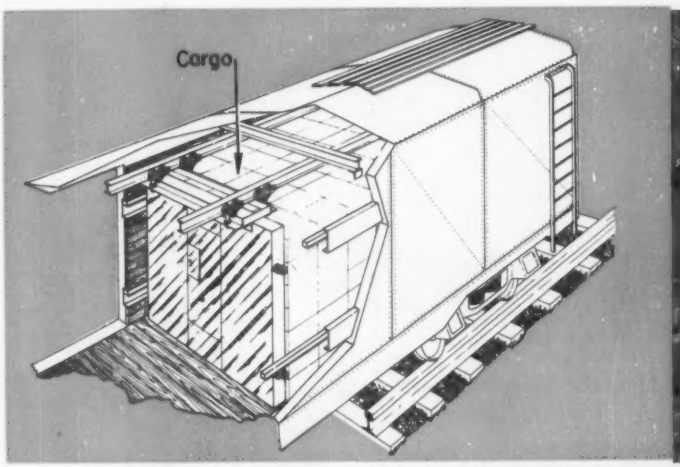
NO TRANSISTORS, RELAYS OR COMPLEX CIRCUITRY mar the Spartan simplicity of the wiring diagram for the phone. Two normally open circuits—one for the microphone, and one for the calling buzzer—are provided with selection keys. The buzzer sets up an audio-frequency signal in the remote station's earphone to call the party. For added simplicity, one connection may be grounded and only one line strung between stations.

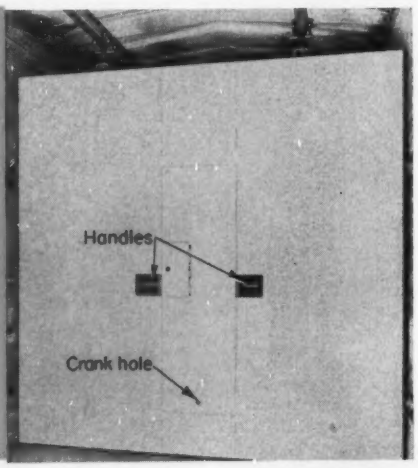


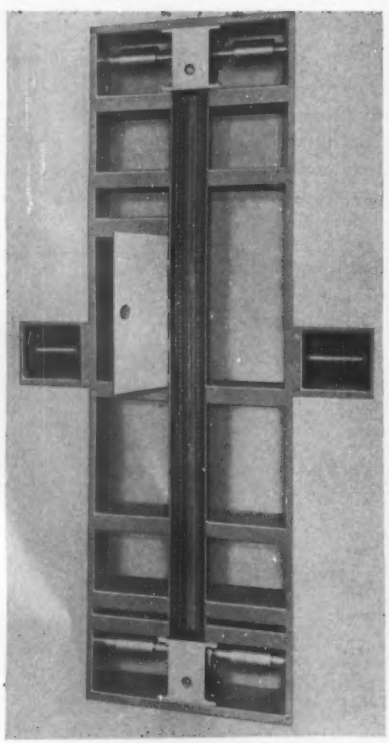
Self - sufficient telephone weighing 1 lb is a product of Standard Elektrik Lorenz AG, Stuttgart, Germany.

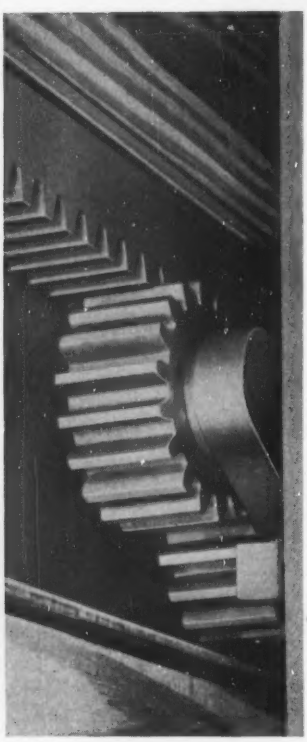
Planetary Pinions Lock Freight-Car Bulkhead against Load

PRESSURE EXERTED on a central crank locks four planetary pinions into place to hold a bulkhead against a cargo. Pinions operate against racks built into the sides of a freight car. The bulkhead travels freely, suspended on overhead trolleys, until it contacts the load. Then the crank is inserted and turned until proper pressure is exerted on the load. The bulkhead exerts 400 psi for every pound pressure on the crank.









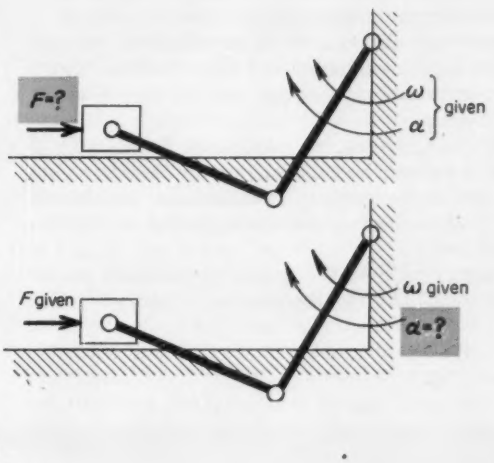
SUN ROTATES TO PRESS planetary pinion into the rack, and then drives the pinion to exert pressure against the cargo. Rack-and-gear locked bulkhead is a development of Anchor Steel & Conveyor Co., Dearborn, Mich.

SPROCKET CHAIN CONNECTS driving worms. Lower worm is operated by the removable crank. Worm and gear assemblies (in boxes) transmit drive to sun-gear shafts.

When velocity and acceleration are known, finding resultant force F, is easy

But

finding the angular acceleration from force F and angular velocity is tough



Here's a direct method for finding accelerations:

Linkage Dynamics *via* Linear Dependence

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Senior Lecturer in Mechanical Engineering
University of New South Wales
Kensington, Australia

THE method of "linear dependence" is a powerful tool for finding the accelerations of all the links in a mechanism when external loads are applied to one or more of the links. It is based upon elementary ideas and yields solutions directly.

The technique applies to mechanisms containing turning or sliding pairs. The examples illustrate the application of the technique developed to a single configuration in a cycle of motion of a mechanism, but not necessarily a configuration at which the inertia effects are greatest.

Further, the velocities of all the links of the mechanism are assumed as already determined for each of the configurations chosen. In this article, most of the accelerations are found graphically by the vector-polygon method. Velocity polygons, too, are the chosen way to establish consistent sets of velocities, but other ways of finding velocities would serve just as well.

Linear Dependence: In a mechanism, as distinct from freely moving objects, each moving point moves in a precise and retraceable relationship with respect to other points. Surprisingly few magnitudes can be chosen independently.

The act of choosing any mechanism of definite proportions establishes a path along which every point will travel as the mechanism undergoes changes from one configuration to another. Directions of velocities are always tangent to the paths and independence in the choice of velocities is limited to one magnitude per configuration.

But the designation of a single velocity per configuration does more than fix all other velocities.

In conjunction with the curvatures of the paths, it fixes the normal components of the accelerations.

Tangential components of accelerations express changes in the magnitudes of the velocities. Again only one velocity magnitude can be altered at an arbitrary rate.

In the ordinary engine mechanism, for example, if either the piston acceleration, or the tangential acceleration of the crankpin is known, the acceleration of any other point in the mechanism is readily determined.

Toward extending the application of these principles of dependence to the solution of more complex problems, a question may be pondered: What is the functional dependence between the accelerations of any two points in a mechanism?

This dependence happens to be linear. That is, if x is the magnitude of the tangential acceleration of a conveniently chosen reference point, P, the acceleration of any other point Y may be expressed by

$$A_Y = xB_Y + C_Y \qquad (1)$$

where the parameters B_Y and C_Y depend upon the momentary configuration of the mechanism as well as upon the relative positions and velocities of the two points.

Consider the accelerations of (motion-transfer) points P and Q on coupler link 3, Fig. 1. In this

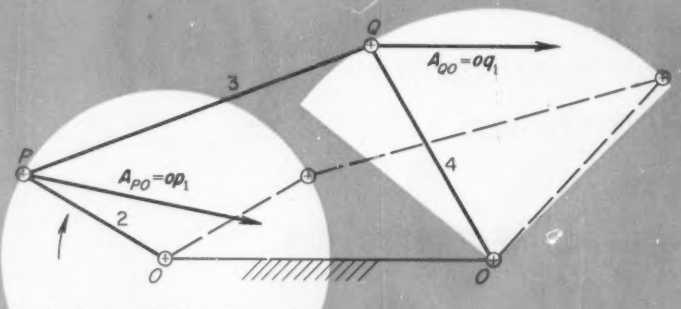

Fig. 1—A typical four-bar mechanism in two configurations.

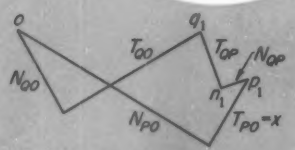

Fig. 2—Components of a typical acceleration polygon.

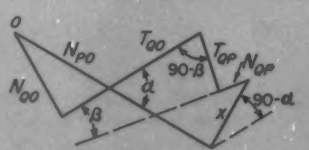

Fig. 4—Angular relations of accelerations in Fig. 2.

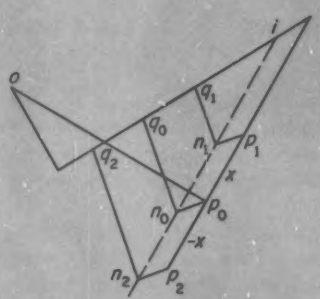

Fig. 3—Three acceleration polygons showing linear dependance of tangential accelerations along the q-line to $\pm x$ tangential accelerations along p line.

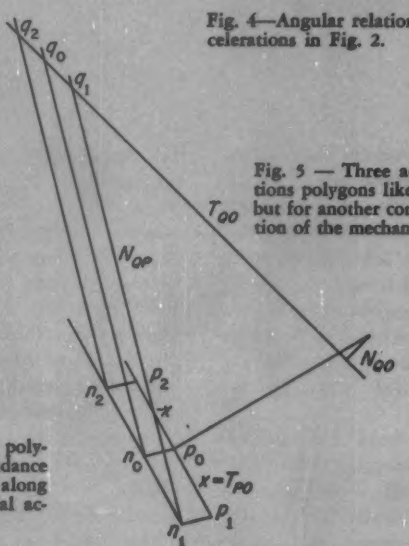

Fig. 5 — Three accelerations polygons like Fig. 3 but for another configuration of the mechanism.

instance the linear dependence of the acceleration of point P with respect to Q is

$$A_Q = xB_Q + C_Q \tag{2}$$

Equation 2 is general and valid for components of accelerations in any prescribed direction. The present discussion is concerned primarily with the tangential components because they affect the inertia forces and torques of moving links. Hence, in terms of tangential components only, the linear dependence is

$$T_Q = xB_{TQ} + C_{TQ} \tag{3}$$

Fig. 2 is a conventional acceleration polygon of the four-bar mechanism represented by Fig. 1. Vector **op**, which appears in boldface to distinguish the vector from its magnitude *op*, defines the acceleration of reference point P. The magnitude of the normal acceleration of **op** is represented by the length N_{PO}; that of its tangential acceleration by $T_{PO} = x$. The normal and tangential components of accelerations **oq** and **pq** are identified in similar fashion, the components of the latter being relative to P.

Usually in the construction of an acceleration diagram like Fig. 2, the tangential components T_{QO} and T_{QP} are the unknowns. Suppose now that the constructions are carried out for two tangential magnitudes x. Fig. 3 is obtained. Regardless of the magnitudes assigned to variable x, all the p points lie along one line; those of q lie along a second line; and those of n lie along a third line, which is parallel to the p line.

Triangles inq are similar. Distances along the n-line, as n_0n_1, are equal to distances x along the p-line. Hence, distances along the q-line are proportional to x. The nq distances represent tangential components of the relative acceleration of Q to P. Thus the relative tangential components, too, are linear functions of x.

The results just demonstrated by the constructions are readily expressed algebraically. Fig. 4 consists of the same vectors as Fig. 2 with the angles designated by α and β. Note that these angles depend only on the configuration of the mechanism. Three sides of the six-sided polygon are of known length. They are the normal acceleration components N_{PO}, N_{QP}, and N_{QO}. Of the other three sides one may be chosen at will. This is called the independent variable $T_{PO} = x$ here. The length of the remaining two sides may now be determined from the condition that the polygon closes (exactly as the equilibrium of concurrent forces in the plane is handled in which two equations enable the determination of two unknowns).

$$T_{QO} = N_{PO}\cos\alpha + x\sin\alpha - N_{QP}\cos\beta + T_{QP}\sin\beta \tag{4}$$

$$N_{QO} = N_{PO}\sin\alpha - x\cos\alpha - N_{QP}\sin\beta - T_{QP}\cos\beta \tag{5}$$

The unknown T_{QP} may be determined directly from the second equation, substituted into the first equation, and then T_{QO} may be found. Clearly, both depend linearly on x, which proves Equation 1, with the constants B and C depending on the velocities and the configuration of the mechanism.

The essential conditions in this proof are: 1. That the directions of the vectors in Fig. 4 are fixed by the configuration of the mechanism, and 2. that the magnitudes of the normal components may be calculated from the velocities. These conditions are general and are also fulfilled in case Coriolis' components of acceleration appear. Angular accelerations are calculated from relative tangential accelerations of two points, on a link (e.g. from T_{QP} for link 3 in the above example) and hence these also depend linearly on the chosen independent variable x.

Fig. 5 shows an acceleration construction similar to Fig. 3, but drawn for the configuration appearing as the dashed lines in Fig. 1. The dependence of T_{QO} on $T_{PO} = x$ is again linear, but the constants in Equation 1 would now be quite different.

Fig. 6 shows linear dependence with Coriolis' acceleration. The tangential acceleration of point Q (on the link O_4Q), shown as q_0q_1, q_0q_2, and q_0q_3 clearly varies in proportion to the tangential acceleration x of point P.

Practical determination of the B and C parameters is usually graphical. It is performed as an extra step in constructing the acceleration polygon. Fig. 3 illustrates the principle. If the nature of the problem is such that the reference point P already has a tangential (or x) component, then the C parameter is established by a construction for $x = 0$. Conversely,

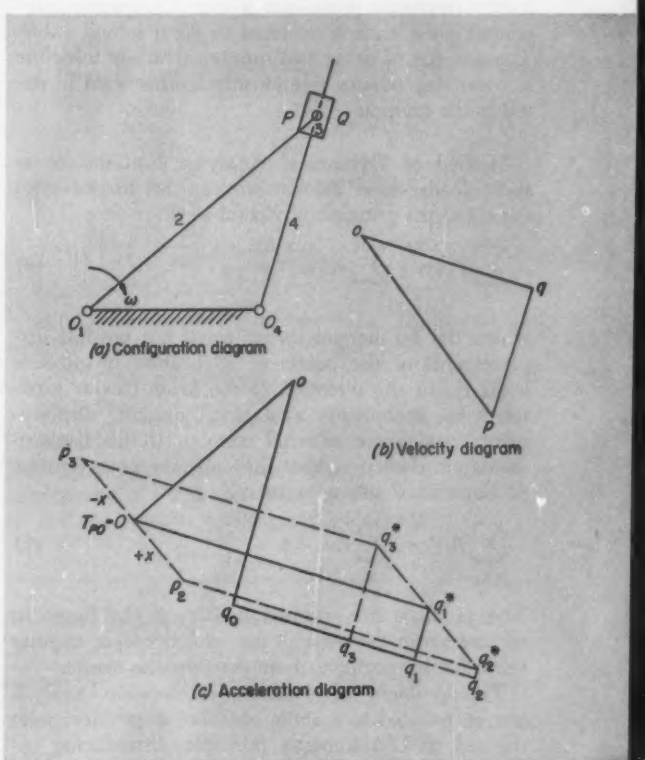

Fig. 6—Linear dependence with a Coriolis' acceleration. Point P moves in a circle of constant radius O_1P. Point Q in link 4 is the momentary point of coincidence with point P.

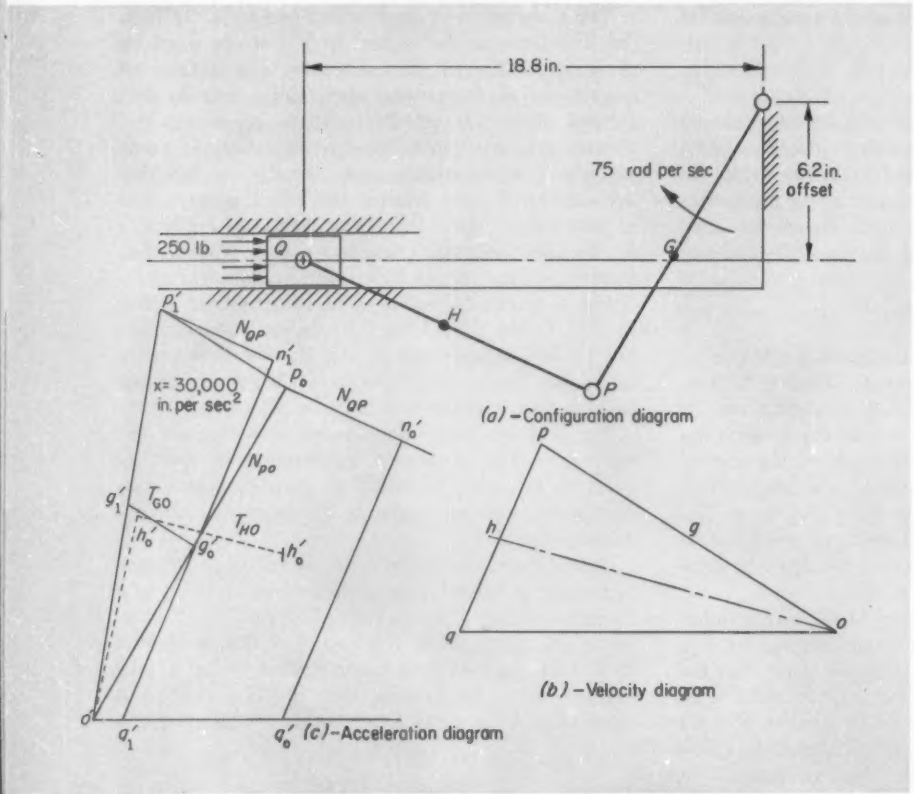

Fig. 7—Three conventional diagrams of a certain offset slider-crank mechanism as they are related to each other for finding accelerations by polygon methods.

if the reference point has a zero tangential component, then an x is assumed to get a second value. The manner of using two numerical values to define a linear dependence relationship is illustrated in detail in the example.

Method of Dynamical Analysis: Equilibrium of static loads on a mechanism can be treated with the aid of the principle of virtual work:

$$\sum_i P_i \delta s_i + \sum_i \tau_i \delta \phi_i = 0 \qquad (6)$$

where the δs_i increments are small but possible displacements of the points of application of effective loads P_i, in the direction of the loads (scalar product), $\delta\phi_i$ increments are small angular displacements, and τ are external couples. If the displacements are chosen so that they all take place in time δt, Equation 6 may be written

$$\sum_i P_i V_i + \sum_i \tau_i \omega_i = 0 \qquad (7)$$

The products are counted positive if the forces or torques act in the sense of the velocities V_i or angular velocities ω_i, negative if in the opposite sense.

The problem of dynamic acceleration analysis can be reduced to a static equilibrium problem with the aid of D'Alambert's principle. Introducing inertia forces, $-m_i T_i$ and inertia torques, $-I_i \tau_i$, and treating them as external loads, Equation 7 still holds. Note that it is the tangential acceleration components that matter. Moments of inertia are to be taken about the center of gravity of each link, while the tangential acceleration components are those of the centers of gravity.

Table 1—Link Weights and Properties

Link or Point	Center-distance (in.)	Weight, (lb)	Center of Gravity (in.)	Radius of Gyration (in.)
Crank, *OP*	13.4	20	7 from 0	5
Connecting Rod, *PQ*	13	8	Midpoint	6
Slider, *Q*	..	5	at *Q*	0

Table 2—Linear Velocities

Point	Vector Direction Fig. 7b	Symbol	Velocity Magnitude (in. per sec)
P	op	V_{Po}	1005
Q	oq	V_{Qo}	1085
	pq	V_{QP}	575
G	og	V_{Go}	525
H	oh	V_{Ho}	1000

Table 3—Angular Velocities

Link	Direction of Rotation	Angular Speed (rad per sec)
Crank, *OP*	Clockwise	75
Connecting Rod, *PQ*	Counter-clockwise	44.3
Slider	Neither	0

Table 4—Normal Accelerations

Link or Point	Vector Direction Fig. 7	Magnitude Symbol	Magnitude (in. per sec²)
Crank, *P*	*P* toward *O*	N_{Po}	75,400
Connecting Rod, *Q*	*Q* toward *P*	N_{QP}	25,400
Slider, *Q*	Vertical	N_{Qo}	0
	Horizontal	A_Q	?

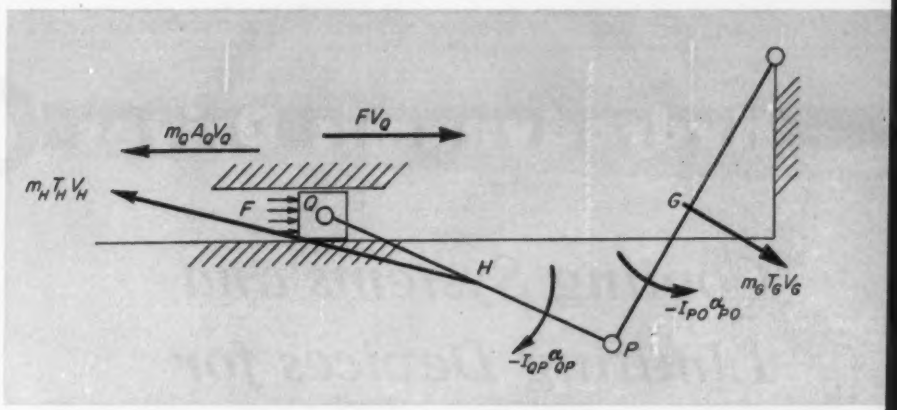

Fig. 8 — Offset slider mechanism to define and illustrate the forces and torques acting upon it.

When the velocities are known and all linear and angular accelerations are expressed in terms of one reference tangential acceleration x, Equation 7 provides a linear equation for x, leading to the solution of the problem.

Example: In the offset slider-crank mechanism of Fig. 7 the instantaneous angular speed of the crank is 75 rad per sec, a resisting load of 250 lb is applied to the slider, and other dynamic properties of the links are listed in Table 1.

WANTED: The tangential acceleration of point P and the angular acceleration of the crank.

Sufficient information is available to find the necessary velocities and normal accelerations. These data are recorded in Tables 2, 3, and 4.

Fig. 8 illustrates the six products needed for substitution into Equation 7. All except one depend upon the unknown tangential acceleration. The next step therefore is to express each of the five unknown magnitudes in terms of an unknown tangential magnitude x of point P. Parameters B and C need to be found for five relationships like Equation 3.

Two values of x are assumed: 0 and 30,000 in. per sec^2. Table 5 records the magnitudes of the various accelerations caused by these assumed values.

LINEAR DEPENDENCE RELATIONSHIPS: Consider now the parameters B and C necessary to establish the magnitude of the acceleration of Q in terms of x. When $x = 0$, $A_Q = -38{,}000$, Table 5. When $x = 30{,}000$, $A_Q = -7000$. Therefore,

$$A_Q = -38{,}000 + \frac{31{,}000}{30{,}000}x \qquad (8)$$

$$= 1.03x - 38{,}000$$

Similarly,

$$T_H = x - 30{,}000 \qquad (9)$$

$$T_G = 0.522x \qquad (10)$$

In the case of the angular acceleration α_{QP}, when $x = 0$, $\alpha_{QP} = 4500$. When $x = 30{,}000$ in. per sec^2, $\alpha_{QP} = 5850$ rad per sec^2. Therefore,

$$\alpha_{QP} = \frac{x}{22} + 4{,}500 \qquad (11)$$

$$\alpha_Q = \frac{x}{13.4} \qquad (12)$$

SUMMARY OF FORCES AND TORQUES: The products indicated by Fig. 8 can now be formed by Equations 8 to 12, inclusive, and data from Tables 1, 2, and 3. Thus,

$$-m_G T_G V_G = \frac{20}{386}(-0.522x)525 \qquad (13)$$

$$-I_{PO}\alpha_{PO} = \frac{20}{386}25\left(-\frac{x}{13.4}\right)75 \qquad (14)$$

$$-I_{QP}\alpha_{QP} = \frac{8}{386}36\left(-\frac{x}{22} - 4{,}500\right)44.3 \qquad (15)$$

$$-m_H T_H V_H = \frac{8}{386}(-x + 30{,}000)1{,}000 \qquad (16)$$

$$-m_Q A_Q V_Q = \frac{5}{386}(-1.03x + 38{,}000)1{,}085 \qquad (17)$$

$$FV_Q = -250(1{,}085) \qquad (18)$$

Setting the sum of Equations 13 to 18, inclusive, equal to zero in accord with Equation 7,

$$x = 12{,}700 \text{ in. per sec}^2 \qquad (19)$$

$$\alpha = \frac{12{,}700}{13.4} = 945 \text{ rad per sec}^2 \qquad (20)$$

Since these quantities are positive, the tangential acceleration of P has the same direction as the velocity, and the angular acceleration is clockwise.

Table 5—Accelerations Resulting from Assumed Magnitudes of x

Point or Link	Identification Fig. 7	For x = 30,000 in. per sec^2 — Linear Magnitude (in. per sec^2)	For x = 30,000 in. per sec^2 — Angular Magnitude (rad per sec^2)	For x = 0 — Linear Magnitude (in. per sec^2)	For x = 0 — Angular Magnitude (rad per sec^2)
P	$T_{PO}=x$	30,000		0	
Crank			2240		0
Slider, Q	oq	−7000	0	−38,000	0
Rod, PQ			5850		4500
G	T_{GO}	15,700	crank	0	crank
H	T_{HO}	−300	connecting rod	−30,000	connecting rod

Note: Negative signs indicate direction opposite to velocity of point or link.

Cooling Systems and Limiting Devices for

Torque Converters

AUXILIARY devices may be required to compensate for characteristics which are inherent in torque converter performance. For example, the power to heat loss must be dissipated to prevent overheating of the converter fluid.

In some applications, a constant output speed is desirable. Or, the torque-multiplying ability of the converter at low output speed may have to be limited to prevent overloading of the other part of the complete machine.

This article discusses various accessory devices for accomplishing these objectives.

Cooling Systems

The power to heat curve shows the actual heat to be dissipated when the engine of an engine-converter unit is operating at full throttle. The heat load at full-throttle operation varies from the maximum at stall to a minimum at the point of highest converter efficiency. The heat load again increases toward race in some type converters.

The heat load can be dissipated by piping fluid from the converter circuit to some type of heat exchanger, and back into the converter circuit again. The heat-rejecting portion and the heat-absorbing portion of any cooling system must each follow the basic heat-balance formula:

$$Q = Wc(\Delta T) \qquad (1)$$

In a shell and tube-type heat exchanger, the engine-jacket water is the cooling medium used to remove heat from the converter fluid in the heat exchanger. The water passes through the tubes and the converter fluid flows around the tubes inside the shell. Ideally, a heat exchanger should have sufficient heat-transfer capacity to reduce the converter-fluid temperature to within 10 F of the high water temperature.

The temperature of the water after it passes through the heat exchanger should be about 200 F maximum to avoid danger of boiling. Therefore, the minimum converter-fluid temperature can be about 210 F. For a maximum converter fluid temperature of 250 F, ΔT would be 40 F.

For example, determine the flow of converter fluid through a type 6, 1500 series converter (as shown in Fig. 9 of article 3) required to maintain a temperature difference of 40 F. The fluid is SAE 10 oil which weighs about 7 lb per gal and has a

Nomenclature

c = Specific heat, Btu per lb-deg F
G = Fluid flow, gpm
N_1 = Converter input speed, rpm
N_2 = Converter output speed, rpm
P_h = Power to heat, hp
Q = Heat load, Btu per min
R_s = Speed ratio
W = Fluid flow, lb per min
ΔT = Temperature difference, deg F
δ = Fluid weight, lb per gal

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specific heat of 0.52 Btu per lb-deg F. Substituting in Equation 1, rearranging, and solving,

$$G = \frac{42.4\,P_h}{\delta c(\Delta T)}$$

$$= \frac{42.4(28.5)}{7(0.52)(40)}$$

$$= 8.3 \text{ gpm}$$

Engine speed at the low 70 per cent efficiency point is 1630 rpm. On a type 6, 1500 series converter with integral pump, the standard pump-drive ratio is 1:1.15 (step-up), giving a pump speed of 1875 rpm. The standard pump for this converter delivers about 10 gpm at this speed. Therefore, the oil-flow rate is sufficient.

The heat exchanger must be adequate to utilize this oil flow, along with the water flow provided by the engine water pump, to dissipate the 28.5 hp heat load. Water flow and temperature conditions vary somewhat with engine design. A high flow of water, held to a reasonable temperature range with a proper thermostat system, reduces the size of heat exchanger required. Lower water flow at higher temperatures, however, requires a larger heat exchanger to dissipate the heat adequately.

A radiator-type oil-to-air heat exchanger can be used to simplify the piping and to reduce the cost, particularly on field conversion installations. The air can be supplied by the engine fan or an independently driven fan. This type of cooling is commonly used on electric-motor converter installations, unless cooling water is available from a plant or municipal water system.

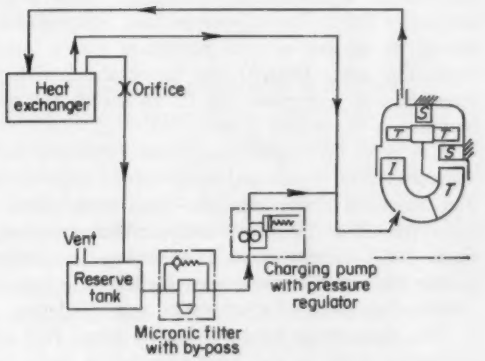


Fig. 1—Cooling system for stationary-housing converter.

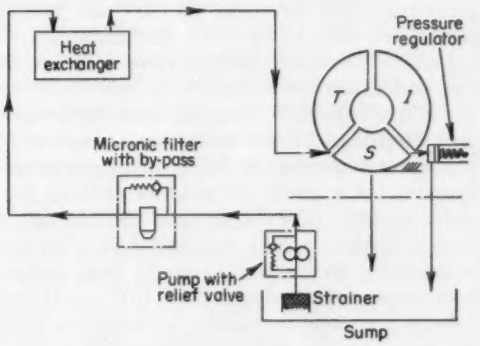


Fig. 2—Cooling system for rotating-housing converter.

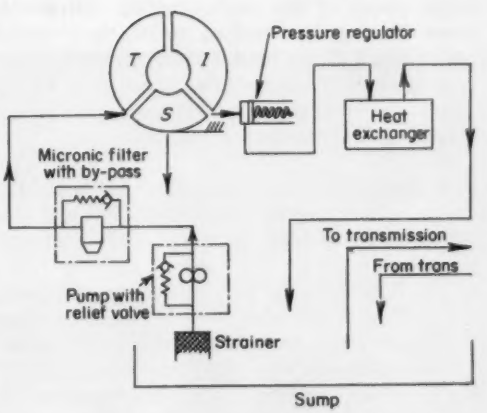


Fig. 3—Cooling system for rotating-housing converter—sump common with transmission.

The oil-to-water method of cooling automatically establishes a minimum operating temperature of converter fluid. The converter-fluid temperature can never be as low as the maximum water temperature. The same benefits can be obtained with thermostats and a bypass line in an oil to air system, but cost of the system is increased.

The need for establishing some minimum for the converter-fluid operating temperature depends upon the converter design and the fluid used. Fluid temperature affects fluid viscosity, which in turn, affects fluid density and flow within the hydrodynamic circuit. All three may slightly affect the converter absorption characteristics and efficiency.

The three-stage converter, with diesel fuel as the converter fluid, is the least affected in performance by viscosity changes due to temperature variations. Even with converter-fluid temperatures down to 100 F, peak efficiency is reduced no more than 1 per cent from what it is at normal operating temperatures. This converter is the least subject to overcooling with an oil to air heat exchanger.

Fluid-temperature changes have more effect on the performance of types 1, 4, and 6 converters which use SAE 10W oil as the fluid. Peak efficiency may drop about 1 per cent from normal at 170 F, and about 2 per cent at 140 F. Efficiency is reduced because, for a given temperature change, the viscosity of SAE 10W oil changes considerably more than does the viscosity of diesel fuel. Therefore, it is advisable to use oil to water heat exchangers with converters which use SAE 10W oil as fluid.

In applications in which the retarding effect of the converter is used, any power which the converter absorbs as a result of the retarding action must be dissipated by the heat exchanger. The freewheel clutch or direct-drive clutch will generally keep the engine—and consequently the fan and water pump of the engine-cooling system—up to speed. During the retarding period, the engine-cooling system will not have to dissipate the full engine-cooling load. Consequently, there will be cooler water and greater heat-dissipation capacity available for cooling the converter fluid.

Stationary-Housing Converter Cooling: Fig. 1 shows a basic piping arrangement for the cooling system recommended for a stationary-housing type converter.

The fluid flow can be produced by the circuit itself if fluid is removed near the outer periphery of the circuit and returned near the center as shown. The impeller acts as a centrifugal pump. The charging pump only maintains a minimum pressure at the inlet to the converter circuit to minimize cavitation within the circuit. Charging pressure is normally 60 psi, but it can be higher if necessary. Higher charging pressures may be necessary on high-speed high-horsepower applications to avoid cavitation. The vent line bleeds air which may accumulate at the high point of the fluid system. It also returns to the reserve tank the small amount of fluid circulated by the charging pump.

Since cooling flow is produced by a centrifugal pump, the amount of flow cannot be determined easily. The head or pressure differential set up between the inlet and outlet of the converter varies approximately as the square of the impeller speed.

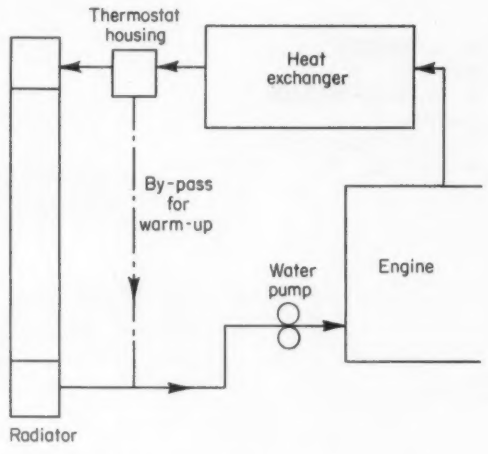


Fig. 4—Cooling water piping system.

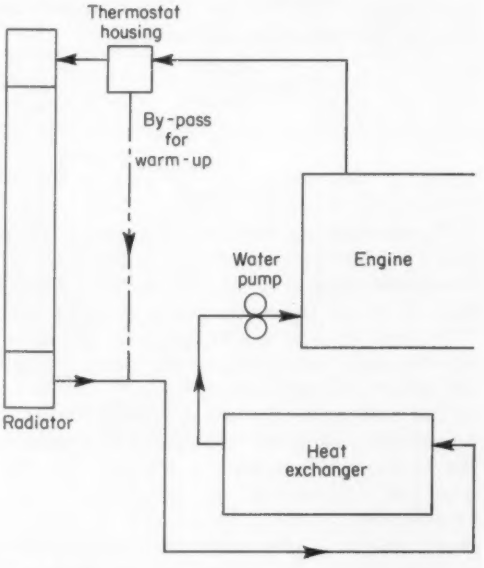


Fig. 5—Alternate system for cooling water piping.

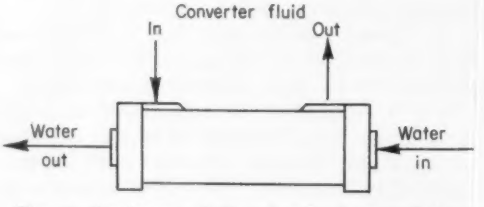


Fig. 6—Single-pass shell and tube heat exchanger.

Excavators and Cranes

Torque converters can be justified economically in excavators or cranes only if they provide improved performance or reduced maintenance costs. An engine can deliver more horsepower hours with the correct converter drive than with a conventional clutch drive, because the converter allows the engine to run at higher speeds even though the output shaft may be pulled down to stall.

A conventional mechanical-drive crane usually has an engine which is capable of supplying sufficient torque to lift its maximum load. When it handles lighter loads—which it does much of the time—the engine works at only a fraction of its capacity. If the crane were equipped with a less powerful engine and a torque converter, the converter would multiply the engine torque to handle the maximum loads. The converter would operate near its power capacity and peak efficiency when handling the smaller normal loads.

The engine of a shovel, dragline, clamshell, or magnet crane operates near peak power much of the time. Thus, its power should not be reduced when a converter is used.

Productivity depends upon the speed of engagement of clutches and the time required to accelerate the machine to its maximum speed. Converters allow more rapid clutch engagement. Some of the slip is transferred from the clutches to the fluid in the converter circuit and the shock of sudden engagements is decreased. Because of this smoothness of clutch engagement and acceleration, the governed speed of the power unit can be as much as 10 per cent faster in a converter-equipped machine than in a comparable mechanical-drive machine.

During normal operation of the machine, it is desirable for the converter to operate near the point of peak power output. The ratio between the converter output shaft and the deck machinery should be selected to provide a deck-machinery speed equal to, or slightly greater than, the normal deck-machinery speed obtained with a mechanical drive. For a three-stage converter, the maximum power output is developed at approximately 0.5 speed ratio. In effect, the converter serves as a 2:1 reduction gear.

The ratio selected must satisfy also the limitation of specified stall torque at the jackshaft. If the stall torque exceeds allowable limits, a ratio with less reduction (or a torque limiter) must be selected. The situation, in turn, requires a lower governed output speed of the converter. An output speed of 0.4 of engine speed is the practical minimum. For a three-stage converter, an output speed of approximately 0.5 of engine speed is considered ideal. Since the three-stage converter has a broad output curve, a variation of rated deck-machinery speed for different digging conditions can be obtained by resetting the output-shaft governor while still maintaining a relatively constant output.

A single-stage converter should be operated at an output-shaft speed of 0.75 to 0.90 of the engine-governed speed. This ratio depends on the performance of the engine-converter combination. Here, as with a three-stage unit, the governed output-shaft speed should be at, or near, the maximum output point because this speed usually corresponds to the range of peak converter efficiency.

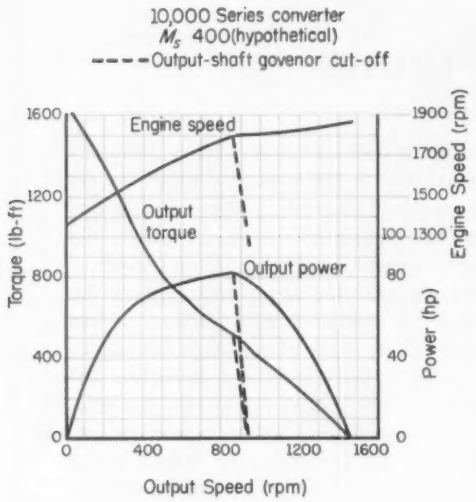
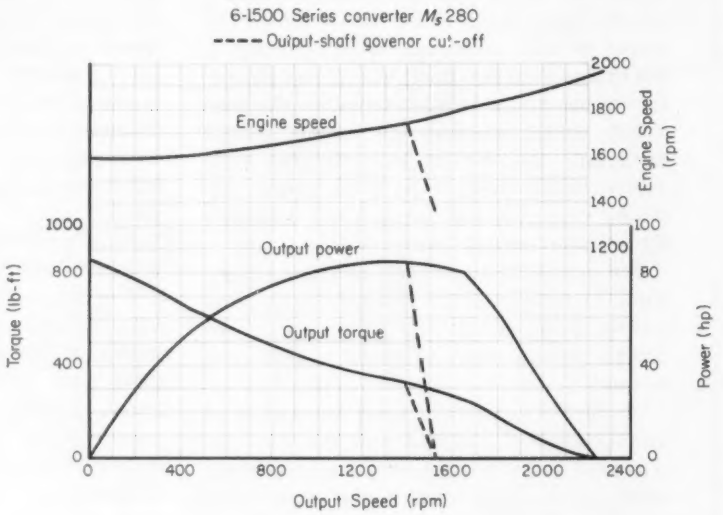
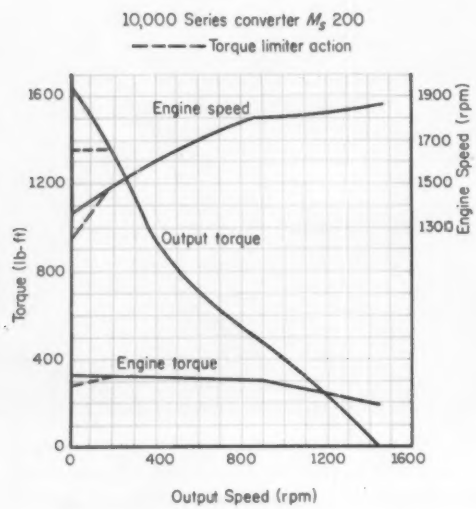


Fig. 7—Above—Performance of example 100-hp engine and three-stage converter with output-shaft governor.

Fig. 8—Right—Performance of example 100-hp engine and type 6 converter with output-shaft governor.

Fig. 9—Below—Performance of example 100-hp engine and three-stage converter with torque-limiting device.





This head will remain virtually the same for a given impeller speed regardless of flow in and out of the converter. However, flow will be determined by resistance of the external piping system.

If the charging pressure at the converter inlet is 60 psi and the discharge pressure at the outlet is 100 psi, the pressure rise across the converter is 40 psi. The flow will adjust to balance a 40-psi pressure drop through the external circuit.

Rotating-Housing Converter Cooling: Fig. 2 shows a basic piping arrangement of the cooling system for a rotating-housing type converter.

Flow is provided by a positive-displacement pump, because fluid cannot be tapped from the outer periphery of the circuit housing. There is little or no natural head to produce flow. All of the flow is provided by the cooling pump, which is driven by the converter-input member.

The heat exchanger should be located between the pump and the converter. Charging the heat exchanger at pump discharge pressure (minus pressure drop through the filter and lines) will help keep the heat exchanger free of air.

In applications in which the converter and the transmission draw fluid from a common sump, it is desirable to have the heat exchanger between the converter outlet and the sump, Fig. 3. This arrangement enables the transmission pump to draw cooled oil, an important consideration if oil-actuated clutches are used in the transmission. With the heat exchanger in this position, the fluid pressure into it is less than if it were piped in ahead of the converter circuit. Therefore, lines must be sized accordingly.

Piping System: Fig. 4 illustrates one method of connecting a converter-fluid heat exchanger into the engine-water system. Water for the heat exchanger is drawn from the bottom tank of the engine radiator, after it has been cooled. The heat exchanger must be connected into the main line so that water

will flow through the heat exchanger when the bypass is open during warm-up. The heat exchanger can aid in the engine warm-up process, because the water will pick up heat from the converter fluid. The heat exchanger should not be piped into the bypass line itself.

The arrangement has one disadvantage. The engine-cooling system receives the water after it has been warmed by the converter fluid. This may not be desirable after the engine is up to operating temperature. Also, the engine water pump must draw through the heat exchanger.

An alternative is illustrated in Fig. 5. The heat exchanger is located between the hot-water outlet of the engine and the radiator top tank. Here again, the heat exchanger must be connected into the main line before the bypass line, to assure full flow at all times.

In a single-pass heat exchanger, the high-temperature converter fluid should enter the same end of the heat exchanger as the high-temperature water leaves it, Fig. 6. In a multiple-pass heat exchanger the connections are not important, so long as the water passes through the tubes and the converter fluid around the tubes.

Speed and Torque Limiters

In some applications automatic regulation of the converter output speed over the full-load to no-load working range is desirable. This is particularly true in excavator applications. Type 1 and type 8 converters approach this requirement with the relatively sharp cut-off of converter output inherent in these circuits. However, the three-stage, type 6, or type 7 converters which are more likely to be used in the excavator application require some device to provide the desired regulation.

Output-Shaft Governor: A simple mechanical flyball type governor can be arranged to reduce fuel to the engine at the desired output-shaft speed. The output-shaft governor should be mounted as close to the engine governor or fuel pump as possible to reduce the mechanical linkage to a minimum.

Fig. 7 shows performance of the hypothetical 100-hp engine and the 10,000 series M_s-200 converter with an output-shaft governor set to cut off engine fuel at approximately the point of peak output power.

There must be some overrun in an output-shaft governor, as in most other governors for industrial applications. Assuming a 10 per cent overrun, the output power goes to zero at 935 rpm, Fig. 7. This value is the no-load speed. Even with this 10 per cent overrun, regulation of maximum output speed is much more positive than if the engine governor alone were relied upon to eventually cut off the engine power and to reduce output to zero. The no-load output speed without the output-shaft governor would be 1450 rpm.

As output power and torque are cut off, engine speed also drops appreciably. The converter passes through its entire speed-ratio range from stall to race, whether or not it is equipped with an output-shaft governor. Therefore, when no-load output speed is reached, the converter speed ratio must be the speed ratio at race. The speed ratio at race is 0.78 for the 10,000 series M_s-200 converter. Engine speed at no load with the output-shaft governor as applied in Fig. 7 is

$$N_1 = \frac{N_2}{R_s} = \frac{935}{0.78} = 1200 \text{ rpm}$$

Fig. 8 shows a similar application of an output-shaft governor on the type 6, 1500 series M_s-280 converter. Output power is cut off at 1400 rpm output speed, and no-load output speed is 1540 rpm.

Torque-Limiting Device: The output torque at stall with a stationary-housing converter is greater than is necessary in some applications. However, it is often very desirable to use such converters for their broad utility ratio. They can be used if some means of limiting the output torque at stall and at low output speed is provided.

Such a torque limiter is available for use with the three-stage converter. It senses the pressure drop which exists across the first row of stator blades at the outer portion of the circuit. This pressure differential is smallest at race and greatest at stall. A pair of pitot tubes, inserted into the circuit, sense the pressure differential, thereby operating a pressure switch. The switch, in turn, controls a solenoid which is connected to the engine governor to reduce speed when torque limiting is required.

Fig. 9 shows performance of the 100-hp engine and the 10,000 series M_s-200 converter. If the application requires a maximum output torque of 1350 lb-ft, the torque limiter can be used to reduce the engine speed, and consequently the torque, when the output torque reaches 1350 lb-ft.

If only one pressure switch were used, the limiter would tend to "hunt" when the converter is working very close to the torque limit. In practice, two pressure switches and a relay are used. The switches are set to open at slightly different values of pressure differential—one at the torque limit and the other 5 to 10 per cent below the torque limit. As output torque approaches the limit, the switch with the lower setting opens. As torque reaches the limit the other switch opens and the solenoid is de-energized. The engine speed is then reduced to the lower speed setting. As output torque decreases and drops below the torque limit, the switch with the higher setting closes first. As torque drops further, the other switch closes and the solenoid is again energized, returning the engine to its normal speed.

It is advisable to arrange the limiter to "fail safe." The solenoid is normally energized to hold the engine at the full-throttle governed-speed setting when output torque is below the limit. Failure of the electrical system causes the engine to go to the lower speed setting or torque-limit setting throughout the entire speed range. Thus, the operator of the equipment would have a definite signal that something is wrong.

Make Your Own Thermocouples

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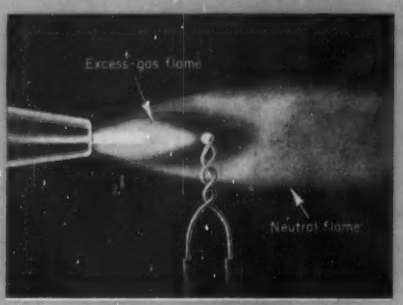

Fig. 1—Welding the thermocouple.

TEMPERATURE measurements of critical accuracy require special thermocouples, tested and supplied with correction data for specific temperature ranges. However, for standard-accuracy applications, Table 1, homemade thermocouples are practical, especially for the lower temperature ranges.

Material Selection: The main consideration for selection of wire and insulation is the temperature range to be measured. Table 1 lists the three types of base-metal wire materials for "average" duty. For most uses, No. 14 B & S gage wire is suitable. To eliminate the need for corrections in the circuit, the thermocouple and lead wire are made continuous.

For use up to 175 F, insulation of vinyl plastic, Buna S, or neoprene offers excellent resistance to deterioration and moisture. Extruded nylon offers similar qualities up to 300 F. For temperatures to 500 F, a high-temperature flame-resistant and moisture-resistant silicone-impregnated asbestos insulation is recommended.

Wire Identification: Wires should be purchased in matched pairs so that a given combination will have limits of error conforming to standard specifications. This practice will avoid the possible mismatching of thermocouple and lead-wire components (constantan wire used with iron is not the same as that used with copper). Table 2 shows the color code used to identify the various conductors.

Making the Thermocouple: The wires are carefully uncoiled to the required length for thermocouple and lead wire. After stripping back 1½ in. of insulation, the oxide is removed from the wires with a fine abrasive paper, and the wires are clamped side by side in a soft-jaw vise. The ends of the wires are then twisted together (at least three turns).

The weld is made with an oxyacetylene torch fitted with a small tip and adjusted to a carburizing flame. No welding rod or solder is used. A commercial flux —or a mixture of six parts fluorspar and one part borax—is used. The torch is clamped in a vise in a horizontal position with the neutral flame adjusted to about 4 in. and the white, excess-gas flame, about ¾ in.

The twisted thermocouple junction is held as in Fig. 1, and slowly rotated until both wires are bright red. The end is dipped into the flux, then replaced in the flame immediately. The wires must be manipulated so that both reach their melting points at the same time (copper, iron, and alumel have the lower melting points in the three basic combinations). As soon as both wires melt, the weld is rotated in the flame to form a ball at the tip of the weld. The remaining flux is removed by dipping the weld in water upon completion. The completed weld is then inspected for evidence of burning.

The weld should be made on the first attempt after fluxing—continued heating usually results in a poor weld.

Table 1—Standard Thermocouple Accuracy

Thermocouple Material	Maximum Temperature (F)	Approximate Error Limit (F) in Range Indicated
Copper-constantan	600	±1.5 from — 75 to 200 ±2.25 from 200 to 500
Iron-constantan	900	±4.0 from —100 to 500
Chromel-alumel	2000	±11.0 from 500 to 2000

Table 2—Wire Insulation Color Code

Material	Positive (+) Conductor	Negative (—) Conductor
Copper-constantan	Copper, blue	Constantan, red*
Iron-constantan	Iron, white	Constantan, red†
Chromel-alumel	Chromel, yellow	Alumel, red

*Sometimes supplied with a blue trace.
†Sometimes supplied with a white trace.

Alignment Charts for

CALCULATING WEIGHT AND VOLUME

of round and rectangular solids

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CALCULATING weights and volumes of various sizes of stock materials can become boring and time-consuming, especially if these calculations are needed frequently during the course of work. To simplify this task, two alignment charts are presented here, one for round-stock calculations and the other for rectangular-stock calculations.

The nomograms are based on the equations for determining weights and volumes of solids. For round stock,

$$W = V\rho$$
$$= \frac{\pi d^2 l}{4}\rho$$

where V = volume, cu in.; d = diameter, in.; l = length, in.; W = weight, lb; and ρ = density, lb per cu in.

For rectangular stock,

$$W = V\rho$$
$$= bhl\rho$$

where b = width, in. and h = thickness, in.

These simple equations contain four or more variables. The simplest parallel-scale nomogram can relate three variables by three scales. More variables introduce "turning" scales.

A unique feature of the nomograms presented here is that four variables are related without need for a turning scale. The trick is possible by the use of a straight edge and right triangle, instead of a straight edge alone. Thus, four variables can be "held" at once during the calculation.

Round-Stock Example: What is the weight of a 2.5-in. length of 1.25-in. round steel stock?

SOLUTION: The chart for round-stock calculations is shown in Fig. 1. Place a straight edge along the line determined by d = 1.25 in. and l = 2.5 in. Then, slide a right triangle along the straight edge to the point where the perpendicular crosses the density scale for ρ (steel) = 0.28 lb per cu in. On the weight scale read W = 0.86 lb.

Quantities beyond the range noted on the scales can be determined by shifting decimal points. For example, if l = 25 in., the procedure is the same, but the answer would be multiplied by 10, and W = 8 6 lb. Of course, a diameter shift of 10 would need to be corrected by 100.

Volume can be found by using unity density and reading the answer on the pound scale. Since unity density is at the far right on the density scale, many calculations will run off scale. Therefore, a density of 0.1 unity can be used. The result need only be multiplied by 10 to give the correct volume.

Rectangular Stock Example: What is the weight of an aluminum bar 0.5 in. thick, 4 in. wide, and 1 in. long?

SOLUTION: The chart for rectangular-stock calculations is shown in Fig. 2. Initially, the procedure is similar to that for round stock. But since this problem contains one more variable than that for round stock, one turning scale is employed.

Place a straight edge along the line determined by h = 0.5 in. and b = 4 in. Then, slide a triangle along the straight edge until the perpendicular crosses the point where l = 1 in. on the length scale. On the volume scale, read V = 2 cu in. By straight edge, connect V = 2 cu in. and ρ (aluminum) = 0.098 lb per cu in., and read W = 0.2 lb on the weight scale.

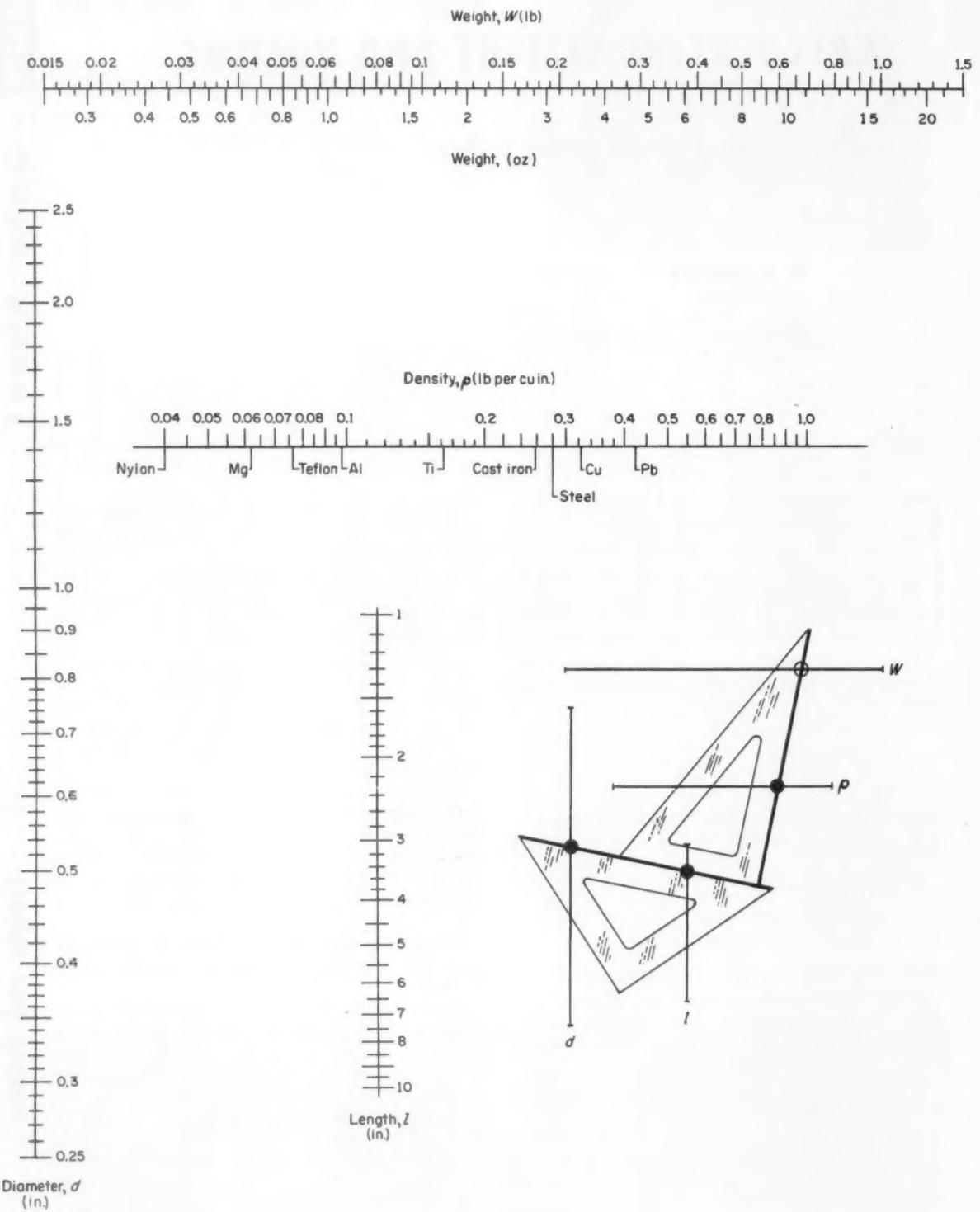

Fig. 1—Nomogram for determining weight and volume of round stock.

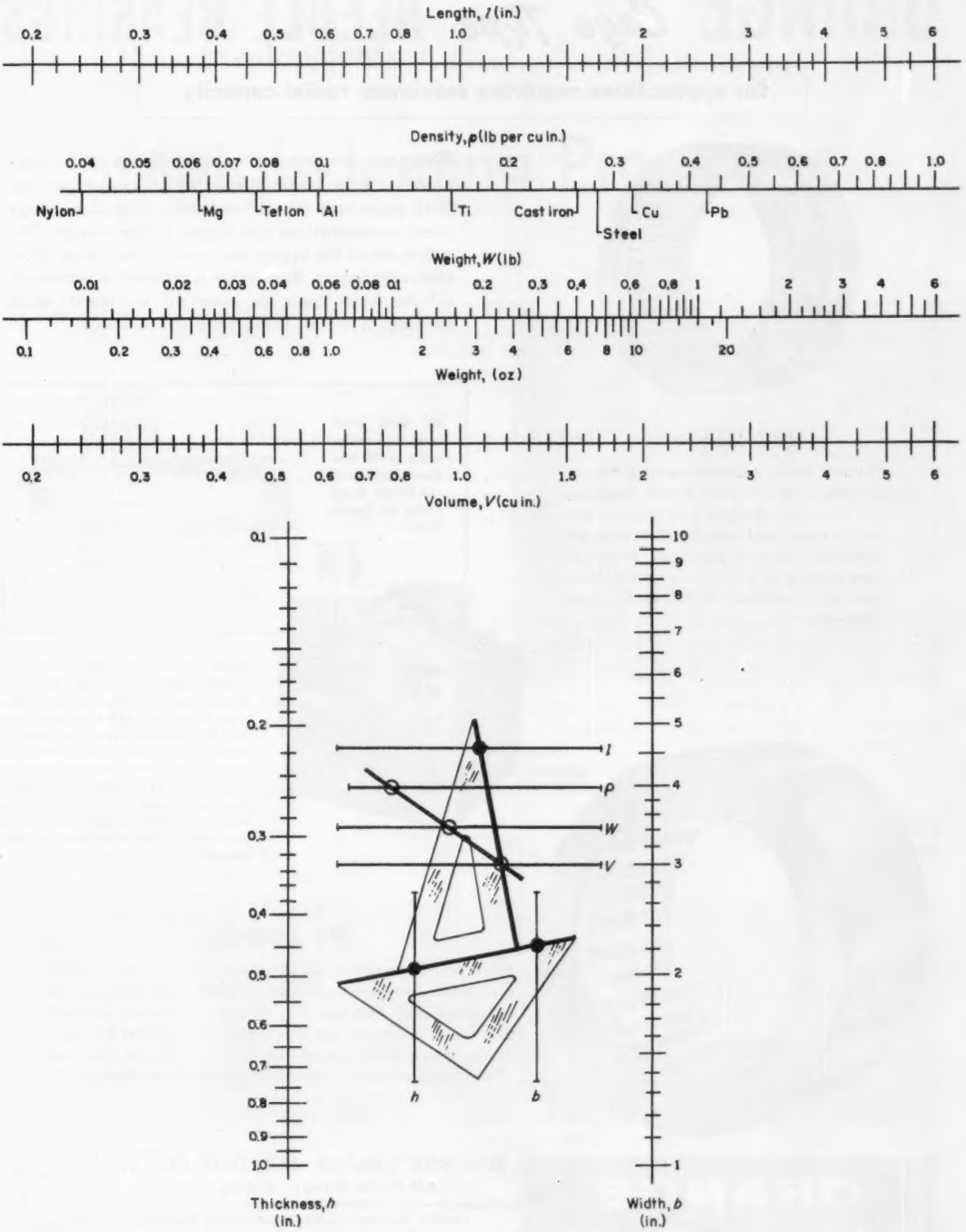

Fig. 2 — Nomogram for determining weight and volume of rectangular stock.

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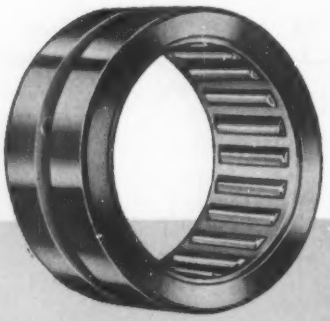

These two new series of needle bearings fill a much-needed place in bearing design for heavy duty service. Both series have relieved-end rollers to minimize high stress concentrations and fatigue at the corners. The rollers are of the square end type for maximum effective roller length. Each roller is retained in pockets of tubular steel cages to maintain alignment while running. Write for engineering specifications.

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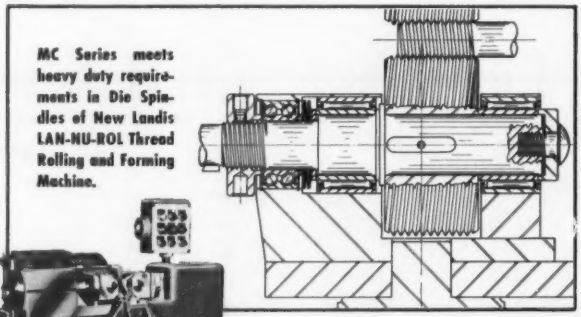
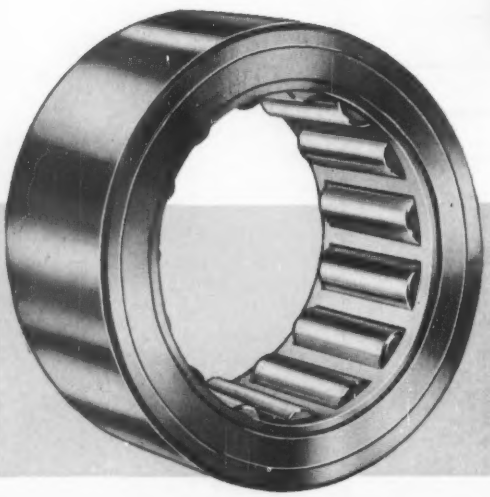


MC Series meets heavy duty requirements in Die Spindles of New Landis LAN-NU-ROL Thread Rolling and Forming Machine.

Faced with limited space and unusually high pressures on its roller die spindles, Landis Machine Company found the answer by installing two MC Orange Cage Type Needle Bearings on each of the 1½″ dia. main spindle shafts. Nominal load on each bearing is 12,500 lbs., or 25,000 lbs. per spindle. During rolling, a maximum pressure point may build momentary load to 50,000 lbs. per spindle.



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New developments in

Metals-Joining Processes

P. J. RIEPPEL
Battelle Memorial Institute
Columbus, Ohio

THE metals - joining field has undergone many changes in the past few years with the introduction of numerous new welding processes and the modification of many existing processes. The purpose of this paper is to review some of these developments and to show the applications and limitations of each new process. An attempt is made to cover any improvement or entirely different process that has been introduced to general use since 1956.

Fusion Processes

Recently developed fusion welding processes involve actual melting of the components which comprise the weldment.

Electroslag Welding: This unique process is particularly suitable for heavy sections. Maximum reported section thickness is 40 in. Welding with the electroslag process is done with the joint positioned vertically, Fig. 1. Welding is started at the bottom of the joint and progresses upwards.

Principal advantages of the process are: No joint preparation is required, thick steel can be welded economically, and heavy equipment can be constructed from small wrought shapes, castings, or forgings. Disadvantages are: Hot-cracking, notch sensitivity in the heat-affected zone, and difficulty in closing cylindrical welds.

Short-Arc and Dip-Arc Welding: Two new arc-welding processes are Linde's "short arc" and Airco's "dip arc." A description that covers both processes would be "low-current, gas-shielded, consumable fine-wire-electrode welding."

These processes differ from other arc-welding processes in that the welding wire short-circuits during part of the cycle. A controlled number of short-circuit cycles occur per second. Due to the cycling and method of transfer, the weld pool remains small and the welding wire is not superheated. A mixture of CO_2 and argon for low-alloy steel welding is suggested for both processes. Wire size, gas mixture, dynamic response, and other variables are about the same for both.

Advantages of these processes are:

1. Skill requirements are lower than those required for stick-type manual welding (flat or out-of-position).
2. Current or heat input is low.
3. Thin sheets can be manually welded with semiautomatic equipment.
4. Poor fitup joints can easily be welded.
5. Spatter loss is low.
6. Distortion is low.
7. Little or no postweld clean-up is required.
8. Deposition rates are high in out-of-position welding and at fast travel.

Limitations are:

1. Small-diameter wire must be used.
2. Penetration and heat input are limited.
3. Deposition rate is low for flat-position welding.
4. Generally available drooping-type power source cannot be used.
5. Cold starts are inherent.

(*Please turn to page 190*)

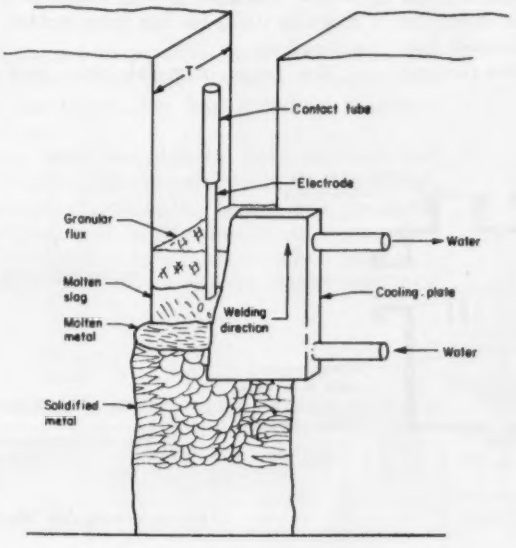


Fig. 1—Elements of the electroslag process

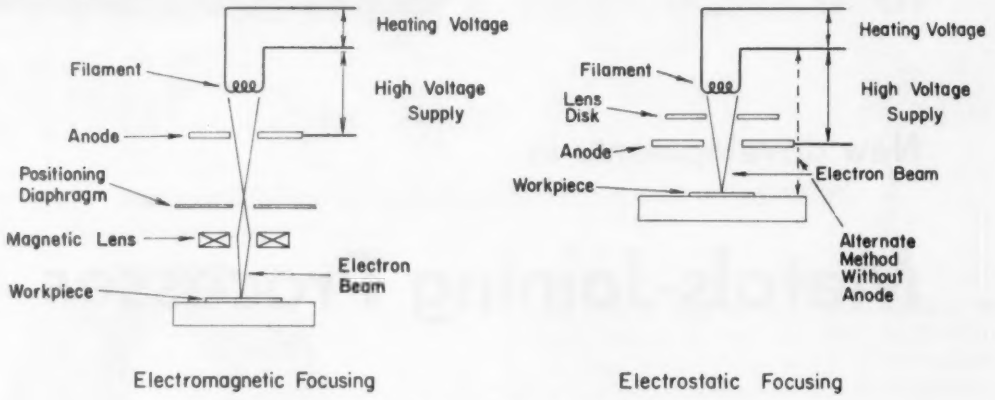


Fig. 2—Arrangement of electron-beam focusing components.

Many materials which have been welded by the tungsten-inert-gas process can be welded faster by these processes. Other materials, such as precipitation-hardening stainless steels and age-hardenable nickel-base alloys, are logical applications for these processes because of the low heat-input characteristics.

Electron - Beam Welding: This process is one of the newest to become commercially feasible. Parts to be joined are bombarded by a stream of high-energy electrons in a vacuum. By concentrating the beam on a small area, sufficient heat is generated to fuse the edges of the workpiece and to permit welding to take place.

Either electrostatic or electromagnetic focusing may be used, Fig. 2 and 3. In electrostatic focusing, the electrons are emitted through a small hole in a plate. Due to electrical lines of force around the hole, the stream of electrons is focused into a narrow beam as it passes through the hole. The electromagnetic focusing system employs a series of magnetic lenses to concentrate the beam. Although electrostatic focusing is simpler, electromagnetic focusing results in a narrower beam and thus a higher concentration of energy. Beam diameters may be $\frac{1}{8}$ to 0.01 in.

The use of deflection circuits, similar to those in a television picture tube, makes it possible to move the beam in any desired manner. Thus, it is possible to make short welds without moving the workpiece.

Focusing the electron beam results in deep penetration and a narrow fusion zone. Single-pass welds can be made in materials up to $\frac{3}{4}$ in. thick. Depth-to-width ratio of the weld joint may be as high as 20 to 1. Electrostatic focusing produces relatively wide and shallow joints. Material with thicknesses down to 0.005 in. has been welded successfully.

The range of metals that have been welded includes stainless and ultra-high-strength steels, and the refractory metals such as tungsten and molybdenum. Limitations on materials that can be welded are related primarily to gas evolution.

Improvements in the welder itself are continually being made. In addition, much effort is being directed toward the automation of the process. Techniques for programming of operations by means of magnetic tape are nearly perfected.

Arc-Spot Welding: The following arc-spot welding processes have been developed, and equipment for each process is available commercially:

1. Inert-gas-shielded tungsten-arc spot welding.
2. Inert-gas-shielded tungsten-arc spot welding with auxiliary wire feed.
3. Inert - gas - shielded metal - arc spot welding.
4. CO_2-shielded metal-arc spot welding.

All four arc-spot-welding methods are used principally as a substitute

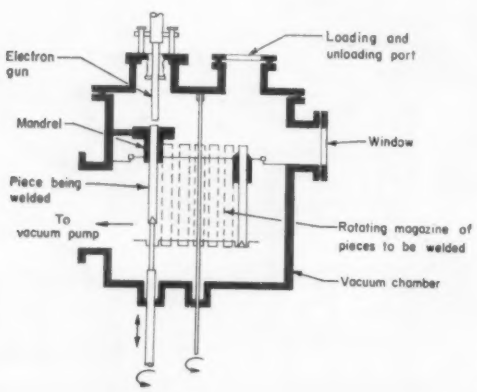


Fig. 3—Production electron-beam chamber.

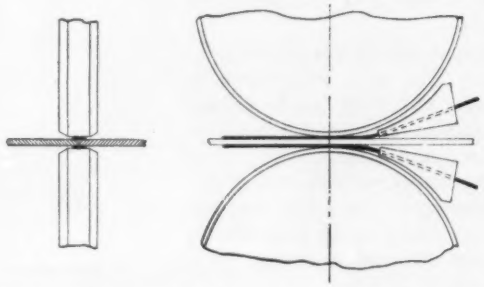
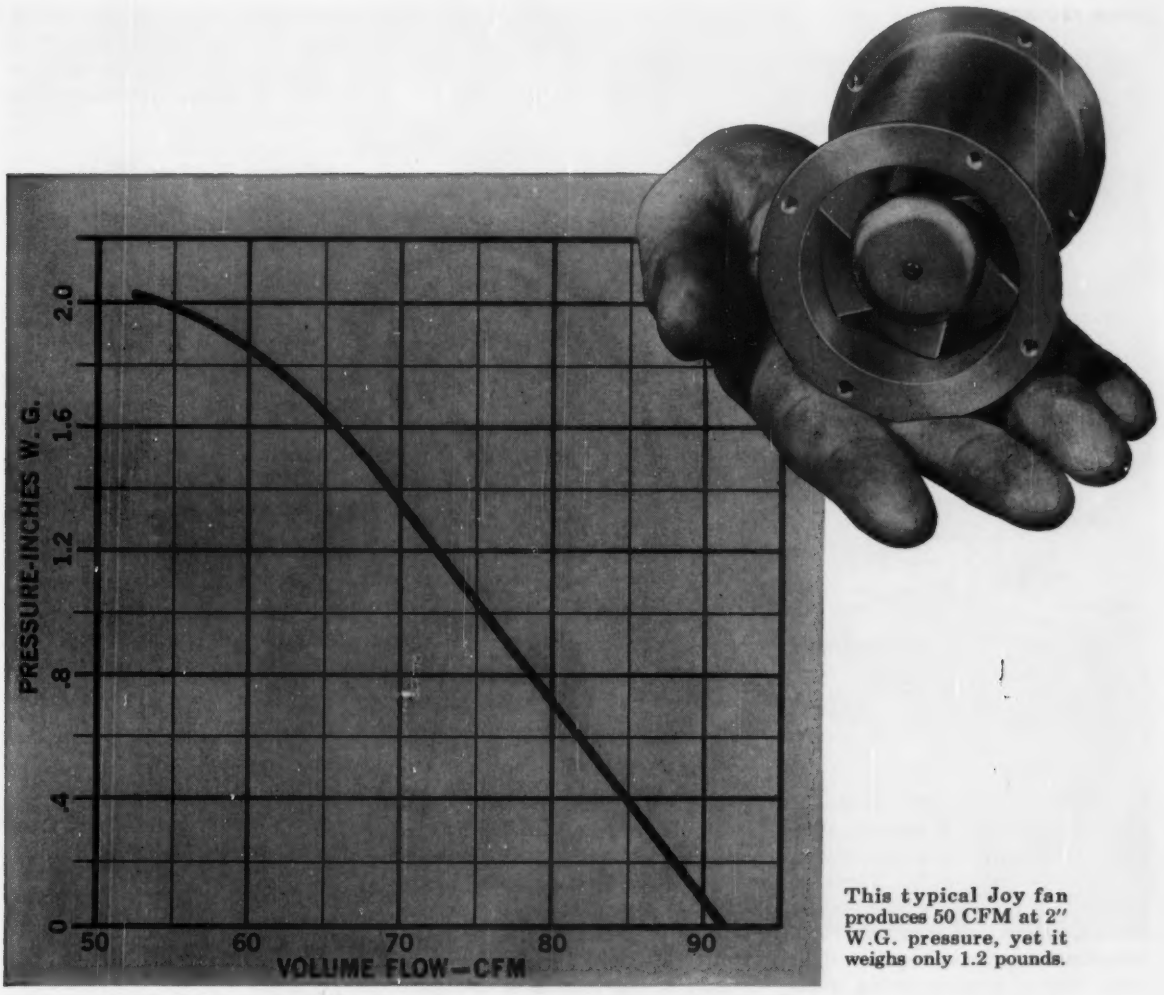


Fig. 4—Arrangement of roller electrodes, foil guide, and workpieces in foil-seam welding.



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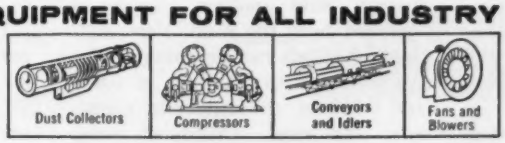

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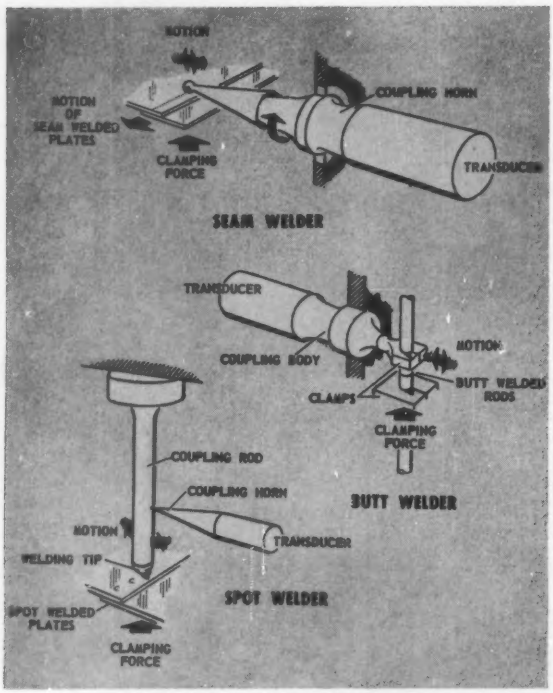

Fig. 5—Basic arrangements in ultrasonic welding.

for mechanical fasteners or resistance-spot welding. A common type of joint that can be arc-spot welded is one between two flat sheets or between a flat sheet and small, formed, structural members. The tungsten-arc process requires tight joint fitup to produce strong welds consistently, but fitup is not critical with the other three processes that add filler metal to the weld. The inert-gas-shielded tungsten-arc process is restricted to joining parts only up to $\frac{1}{8}$ in. thick. Good welds can be made between sheets of 1100 aluminum alloy up to sheet thickness of 0.1 in.

Arc-spot welding processes make localized fusion welds by holding an arc in fixed relationship with the work for a period of 1/10 to 6 sec. The arc produces a tapered fused area that must penetrate completely through the upper part. Penetration of the fused zone into the lower part may vary up to 100 per cent of the thickness.

Arc-spot welds can be made with access to only one side of the work, whereas resistance-spot welding normally requires access to both sides. Because filler metal is added to the weld in three of the arc-spot welding processes, these processes can be used to weld parts that do not have good fitup. Arc-spot welding equipment also can be used for making tack welds.

Economical and technical factors may prevent the use of arc-spot welding in certain applications. Arc-spot welds cannot be tempered as a part of the process in the same way the resistance-spot welds are tempered. Tungsten-arc spot welding leaves an irregular surface, and the other three arc-spot welding processes that add filler metal to the weld cause metal buildup or a button at the weld.

Resistance Welding

Resistance-welding processes depend on resistance heating effects in the parts being joined. New developments include several new processes and improved controls for existing equipment.

High-Frequency Welding: This process is particularly useful for high-speed production of tubing. The depth of heating usually is very shallow and molten metal is squeezed from the weld. Very high welding speeds can be obtained; for example, 100 to 500 fpm in 0.081 and 0.010 in. thicknesses in aluminum and steel. Dissimilar metal combinations also can be welded. Thickness range is 0.004 to 0.125 in. The best use of the process is in applications where continuous runs can be made.

Foil-Seam Welding: The foil-butt seam-welding process is similar to conventional seam welding except that a thin, narrow strip of metal is introduced between the parent metal and one or both of the welding electrodes, Fig. 4. The strip usually is 0.010 in. thick and $\frac{1}{8}$ to 5/32 in. wide.

Advantages of foil-butt seam-welding include: Strong leakproof joints, minimum joint thickness, good appearance, ease of finishing, high welding speed, and little deformation of parts.

Magnetic-Force Welding: With this process, the welding force is created by an electromagnetic instead of by conventional hydraulic or pneumatic cylinders. One advantage of this method of force application is that more heat is generated by a given current because of the higher contact resistance that accompanies low electrode force. The resulting heat is concentrated near the weld faying plane and permits welding vinyl-coated steels and other prefinished material with no damage to the finish. The process also has been used to make large area welds with shallow heat penetration.

High-Temperature Brazing

One of the more important advances in the joining field in recent years is the use of brazing techniques to join assemblies for high-temperature service above 1200 F. In many instances, brazing has proved to be the most acceptable joining procedure because of the type of material being joined, the joint configuration, or the thickness of metal involved in the joint. The heat-treating cycle of high-temperature alloys requires the use of brazing alloys which permit brazing to be done simultaneously with heat-treatment, or do not interfere with heat-treatment.

Heavy Sections: Many high-temperature brazing alloys are available for joining relatively thick materials. Among the more common alloys used for brazing are the Ni-Cr-Si-B

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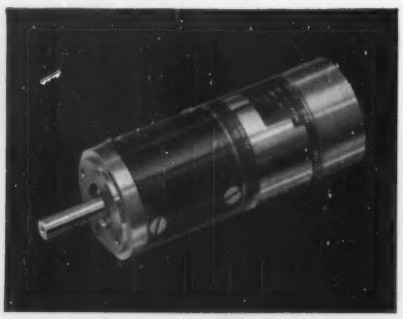

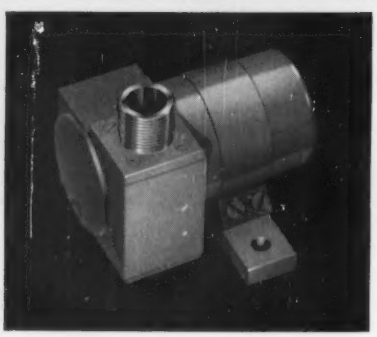

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alloys, the Ni-Cr-Si alloys, and the Ni-Si-B alloys. Most of these alloys melt at temperatures near 2000 F and can be used in a hydrogen atmosphere. They produce joints with excellent high-temperature properties in many of the available base metals.

Thin Sections: Many high-temperature brazing applications involve the joining of thin metal sections 0.100 in. thick and less. Choice of brazing alloy and brazing technique is limited severely because reaction between the base metal and the brazing alloy must be minimized.

Special heating techniques have been devised to provide very short brazing cycles to minimize distortion of the finished panel. Among these are the use of radiant-gas heating, induction heating, and quartz-lamp radiant heating.

Special Techniques: Cermets are used frequently for high-temperatures service, and it is usually necessary to join the cermet to a metallic section. Cermets are cemented hard metals and oxides, and generally contain oxides, carbides, and borides of various metals. Because of their composition, cermets are not readily wet by most brazing alloys. In addition, the coefficients of thermal expansion of metals and cermets vary considerably, and cracking in the joint may occur. It is sometimes necessary to provide a transition layer of an additional metal to reduce the thermal coefficient gradient.

Future Developments: Research is being conducted on a wide scale to develop new and improved alloys for joining purposes. Much of this work is concentrated in areas where thin sections must be joined. The goal of such programs is the development of brazing alloys with the requisite high-temperature properties, but without the tendency to react with the base metals.

Solid-State Processes

Difficulties in stating how a bond is made or what constitutes a good joint have hindered the application of solid-state processes. Despite these

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hindrances, important developments have been made in processes that probably involve solid-state bonding. These processes are: Ultrasonic welding, friction welding, diffusion bonding, and explosive welding.

Ultrasonic Welding: In ultrasonic welding, the surfaces to be joined are made to slide in contact under a compressive force, Fig. 5. The force assures intimate contact by removing oxide layers and surface peaks. Clamping forces are supplied by hydraulic or pneumatic cylinders or an electromagnet. The work done in sliding heats the interface to a point where the metals will interact and join. Advantages of ultrasonic welding are:

1. Very thin-gage materials can be welded.
2. Surface preparation is not critical.
3. Minimum surface deformation is obtained.
4. No contamination occurs from gases and arcs.
5. Thin sections can be welded to thick sections.
6. Dissimilar metals can be joined.
7. Melted or heat-affected zone is minimized.

Disadvantages are:

1. Heavy-gage material is not weldable.
2. Materials being welded tend to weld to the coupling and anvil.
3. Equipment life is short due to fatigue.
4. Very ductile materials will yield under ultrasonic strain without sliding.
5. Hard materials will fatigue under the stresses necessary for welding.

Studies so far have given limited information about the possible uses of ultrasonic welding. However, it is known that butt, seam, and spot welds can be made in thin-gage sheets of moderately ductile materials such as mild steel, iron, aluminum, copper, and gold. In addition, it is known that thin sheets of plastics can be joined by ultrasonic welding.

Friction Welding: In this technique, welding is accomplished by rotating one piece under pressure against the other piece which is held stationary. After sufficient heat for welding is generated by friction, rotation is stopped and the clamping force between the two pieces is

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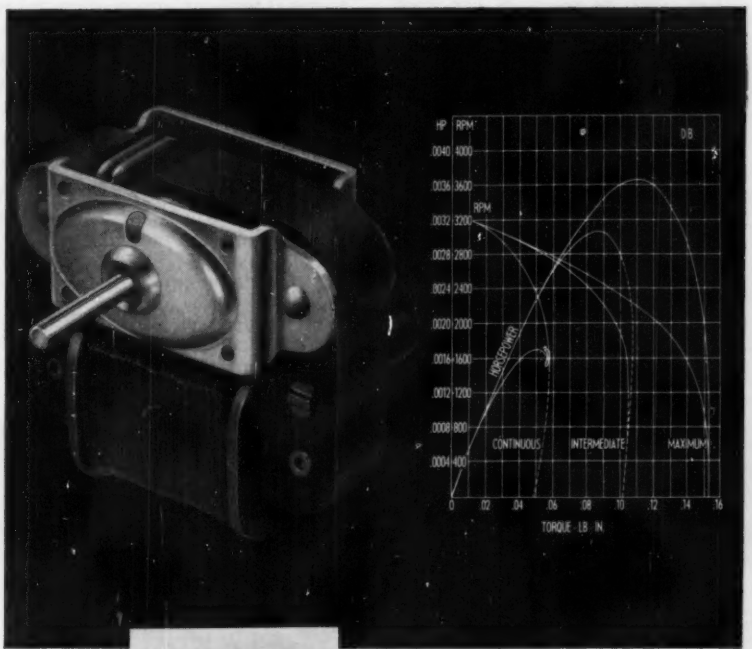

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increased, welding the two pieces together.

Advantages of friction welding include simplicity of operation and low-power requirements. For a high-production application, friction welding is ideally suited for automation. Further, surface cleanliness presents no problem. Various surface impurities and oxide films are broken up and thrown off during the friction-heating process.

Friction welding has been applied generally to the joining of small pieces, such as pieces of bar stock. It may be used for the welding of pipe and pipe flanges to flat sheets.

Diffusion Bonding: As treated here, diffusion bonding is a joining technique in which coalescence of closely fitting parts is obtained by applying pressure. Heat is usually applied with pressure, but is not always necessary. The effect of heat is to increase the rate of diffusion and to decrease the time required to make a joint. The effect of pressure is to reduce surface roughness and to promote closeness of fit.

Diffusion bonding can be used without significantly changing the physical properties of the base metals. Other advantages are:

1. Formation of embrittling compounds can be controlled and minimized.
2. Scrap losses can be kept low.
3. Joining and heat-treatment can sometimes be accomplished in one operation.
4. Need for added filler metals can be either eliminated or their use mitigated by diffusion.

There are three common joint systems for diffusion bonding: Metal-to-metal without intermediate materials, metal-to-metal with intermediate materials, and metal-to-ceramic materials. Intermediate materials, properly chosen, permit lower temperature bonding, give better control of the formation of detrimental intermetallics, can increase bonding rate, and, when plated on the base metals, eliminate problems associated with base-metal composition.

Explosive Welding: Recent developments using explosives for joining and cutting of metals are promising for the future. However, the process is still in its infancy. Several fabricators have used explosives to join similar and dissimilar metals. Both fusion and nonfusion methods have been reported. From these data, it seems that different metals or different groups of metals require variations in technique.

SAE Paper No. 160 B, "Applications and Limitations of New Development in Metals Joining Processes," presented at the SAE National Aeronautic Meeting, New York, April, 1960, 18 pp.

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Lt. Comdr. Frank W. Anders, U. S. Navy Bureau of Ships

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SAE Paper No. 159A, presented at the SAE National Aeronautic Meeting, New York, April, 1960, 2 pp.

bearings

Power Loss in Bearings Due to Cavitation

Leif Floberg, Chalmers University of Technology, Gothenburg, Sweden

Agreement between theory and physical experiments for power-loss determination in journal bearings. When power loss in a bearing is calculated, the problem is how to determine the loss for the cavitation region. There are both oil and air strips in this region. Due to the low viscosity of air, the air strips give negligible power loss. Therefore, the extension of the oil strips in the cavitation region must be accurately considered. In this paper, these conditions are rigorously followed, and the tests show good agreement with theory.

"Experimental Investigation of Power Loss in Journal Bearings, Considering Cavitation," Transactions of Chalmers University of Technology. Gothenburg, Sweden, No. 215, 1959, 16 pp.

techniques

Techniques for Parts Handling

Robert H. Bonner, application engineer, Radio Corp. of America

Design features and selection of parts feeders. Basically, parts feeders can be broken down into two groups: Bulk feeders and orientation-type feeders. Bulk feeders discharge parts at a controlled rate to bulk-processing operations. Volumetric accumulators can be incorporated to release given volumes of bulk parts in accordance with electrical signals.

Orientation-type feeders store a certain volume of parts in bulk, and select and discharge them in a single row, all oriented the same way. There are several types of these feeders: Orienting belt, rotary, vibratory, non-mar, and stack. The orienting belt type is most suitable for feeding relatively simple parts of medium size (no dimension smaller than ½ in. or larger than 3 or 4 in.).

Rotary hopper types are available with bowl diameters from 6 to 36 in. These hoppers are suitable for handling part sizes up to 2 in. They are capable of high rates of feed and will orient more complicated shapes than orienting belt type hoppers. One type of rotary hopper accomplishes orientation by using a machined selector ring. Other types perform part orientation on their discharge tracks.

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Stack hoppers are used primarily to feed rods ranging in size from $\frac{1}{8}$ to 1 in. in diameter and from 4 to 24 in. in length. The hopper is essentially a storage box with an agitator which causes the parts to roll out the bottom in a single row. A pusher can be incorporated to discharge one part at a time when energized by an electrical signal.

"Techniques for Parts Handling," presented at the Fourth Conference on Manufacturing Automation, Purdue University, April, 1960, pp. 56 to 60, collected conference papers.

materials

Effect of Silicon on Corrosive Wear in Cast Iron

R. Graham, O. S. Prado, M. H. Collins, E. A. Brandes, and H. K. Farmery.

Determination of optimum silicon content in cast iron subject to corrosive wear. Prevention of wear is primarily a matter of lubrication although materials and their metallurgical structure can also be important. This is true especially where operating conditions are severe and where boundary lubrication obtains over a significant part of the operating cycle. A grey iron is generally recommended for this purpose. In practice, the desired properties are most readily obtained with a silicon content between 1 and 3 per cent.

In a corrosive environment, metal may be lost through corrosive wear. It is well known that high-silicon irons have good resistance against corrosion. It seems to have been assumed that the silicon content of a cast iron toward the upper end of the 1-3 per cent range provides optimum resistance to abrasion and corrosive wear. This paper presents

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Circle 517 on Page 19

evidence that cast irons with a silicon content of 2 to 2½ per cent have the least resistance to corrosion by acids, and that a reduction of the silicon content to about 1 per cent can improve the corrosion resistance several fold.

Paper No. 30/59, "Influence of the Silicon in Cast Iron on Corrosive Wear," prepared for The Institution of Mechanical Engineers (Great Britain), 10 pp.

lubrication

Bearing-Lubricant Systems For High-Temperature Service

William J. Anderson and Edmond E. Bisson, Lewis Research Center, NASA, Cleveland

Approaches to the problems of high-temperature bearing lubrication. These involve various types of lubricants as well as different lubrication techniques.

Based on results of limited research programs, the following bearing-lubricant systems appear to be the most promising for high-temperature applications (no order of priority is implied):

1. Gas-lubricated hydrodynamic and hydrostatic bearings.
2. Liquid-metal-lubricated hydrodynamic and hydrostatic bearings.
3. Organic-liquid-lubricated rolling-element bearings with a "once-through" system.
4. Organic-vapor-lubricated rolling-element bearings.
5. Dry-powder-lubricated rolling-element bearings.
6. Reactive - gas - lubricated rolling - element bearings.
7. Self-lubricated rolling-element bearings.

SAE Paper No. 176D, "NASA Research on the High-Temperature Bearing Problem," presented at the SAE National Aeronautic Meeting, New York, April, 1960, 12 pp.

Lubrication of a Cylinder Rolling on a Plane Surface

Leif Floberg, Chalmers University of Technology, Gothenburg, Sweden

At a contact area such as that between a cylinder and a plane surface, there must always be a cavitation region due to the continuity condition. In this paper the continuity is satisfied in every section

14 WAYS THE SILICONES MAN HAS HELPED AMERICA'S MOBILE MILLIONS

Silicones are now used to improve the quality, durability and operation of many of today's automobile parts. They also aid in many of the production processes. Tires slip easily from intricate molds coated with silicone release agents. So do rubber floor mats and radiator hose. Silicones are used in making shell molds for crankshafts, camshafts, and valves. Damped with silicone fluid, dashboard instrument needles stay steady over bumps. Silicone rubber sparkplug boots resist water, ozone, high heat for tens of thousands of miles longer. Electrically conductive silicone rubber ignition wire cores can reduce car radio interference. Silicone fluids save power by cutting out the radiator fan at high speeds. The actual foaming of polyether cushioning used in seats, arm rests and crash pads is closely controlled by silicone surfactants. Curiously, silicones also *prevent* foaming of rubber latex used for carpet backing. Beneath many cars, silicone rubber gaskets seal in hot transmission fluids, and prevent leakage of oil from differentials. Outside your car, silicones are the leveling agents for acrylic lacquer. They're all-weather lubricants for weatherstripping, giving longer wear and better moisture resistance. And they're the vital ingredients that make car waxes quick and easy to apply and polish. All this for just one industry. Is your business getting the most out of silicones? If not, call the UNION CARBIDE Silicones Man. Silicones Division, Dept. FL-0001, Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y.

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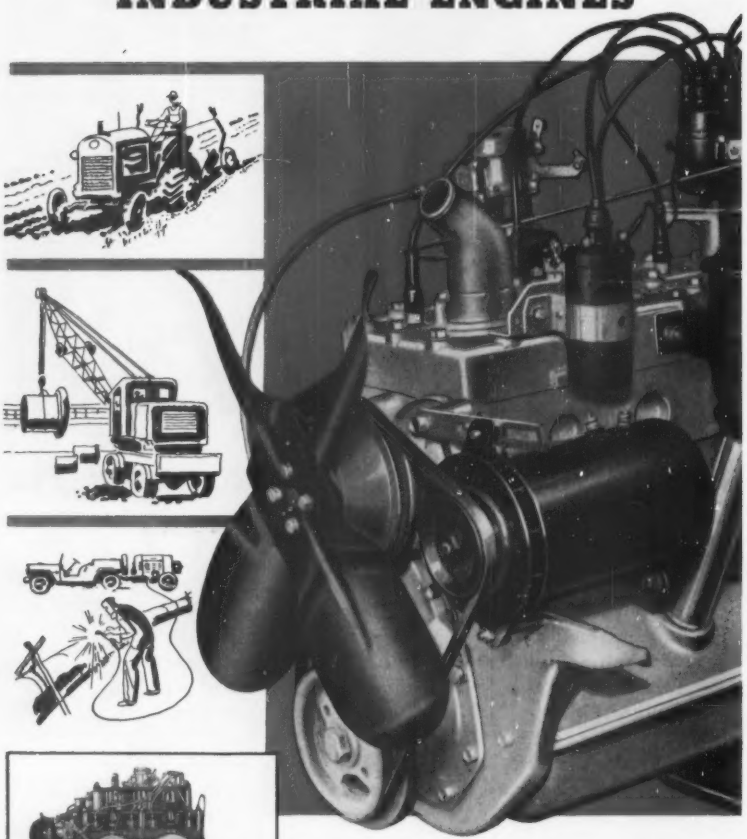

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of the oil wedge, and the cavitation is considered. The continuity prescribes zero pressure derivative at the beginning of a cavitation region. The boundary at the starting point of the oil film depends on the oil quantity supplied. When power loss is calculated, the air strips in the cavitation region are taken into account. The width of the cylinder is assumed to be infinite.

Ordinarily the circular surface is approximated to a parabolic surface. Here the original circle is used to get theoretically correct boundary conditions. If a parabola is used, the two theoretical boundaries are located at infinity. The parabola method, however, is mathematically easier to use and gives very good results.

"Lubrication of a Rotating Cylinder on a Plane Surface, Considering Cavitation," Transactions of Chalmers University of Technology, Gothenburg, Sweden, No. 216, 1959, 40 *pp.*

mechanical

Geometry of Linkage-Geneva Mechanisms

K. H. Hunt, Monash University, Melbourne; N. Fink, United Carpet Mills, Melbourne; and J. Nayar, Aircraft Development Unit, Laverton, Victoria, Australia.

Geneva mechanisms in which the driving pin is attached to the coupler of a four-bar chain, so that the driving pin follows some noncircular closed curve. By this device the output acceleration can be reduced to zero at engagement and disengagement. The completed mechanisms all reduce to six-bar linkages which are amenable to kinematic analysis in the usual manner.

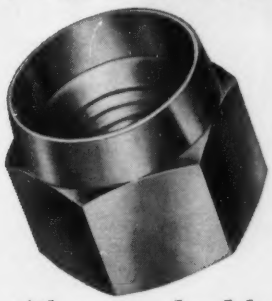
Paper No. 32/59, *"Linkage Geneva Mechanisms. A Design Study in Mechanism Geometry," prepared for The Institution of Mechanical Engineers (Great Britain),* 16 *pp.*

Operation and Applications Of the Thermionic Converter

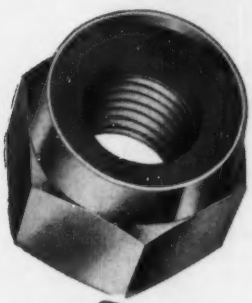
James G. Leisenring, General Electric Co., Missile and Space Vehicle Dept., Philadelphia.

A simplified description of the thermionic converter and its operating principles. The converter may

UNSHAKEABLE SELF-LOCKING PERFORMANCE IS BUILT INTO AN ELASTIC STOP® NUT



Start with a standard hex nut and add a metal crown . . .



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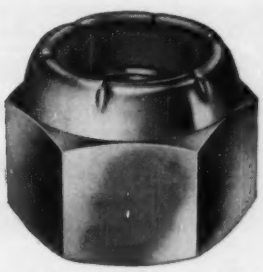

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INSIDE STORY

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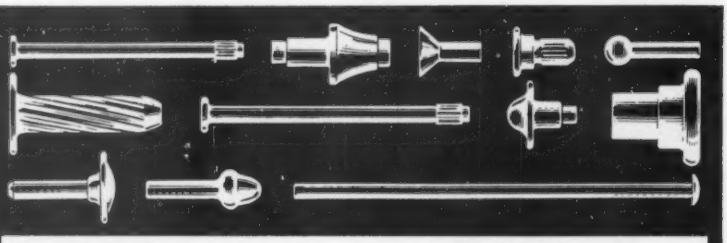

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be used as an electrical power generator or high-temperature sensor in space, airborne, ground, or subsurface systems.

The thermionic device converts heat energy directly into electrical energy by utilizing thermionic emission. It consists, fundamentally, of a metallic cathode heated sufficiently to emit electrons and sustain the required heat flux. The most common types of thermal sources are solar, chemical, and nuclear. In this paper, a solar-thermionic space-power system is analyzed in detail.

SAE Paper No. 159C, "The Thermionic Power Converter and its Applications," presented at the SAE National Aeronautic Meeting, New York, April, 1960, 28 pp.

Analysis of Buckling Column Spring

Alexander Blake, head, Applied Mechanics Section, Research Center, Associated Spring Corp.

Design equations and working charts for predicting load-deflection characteristics and maximum bending stresses in buckling-column springs. Discussion deals with initially straight springs of uniform cross section, considered to be pin-jointed at the supports. Load-deflection analysis is based on the study of a slender bar, compressed beyond critical buckling.

Studies show that a greater portion of the load-deflection characteristics of a thin strip of steel, loaded as a round ended column, may be utilized in spring design when low rate and relatively large deflections are specified. Based on the present study the recommended range of deflection to free length ratio ε is 0.05 to 0.40.

Design equations and charts, derived on the basis of classical Lagrange theory, aid in the preliminary calculation of load-deflection curves and maximum bending stresses.

Although no experimental investigation of bending stresses was made, calculations appear to indicate that appreciable fiber stresses can develop in a buckling column spring for larger ratios of ε.

Care should be exercised in selecting the thickness of stock since the tolerance is often difficult to maintain in manufacture, and to measure

Circle 522 on Page 19

with sufficient degree of accuracy. This is especially important in designs utilizing thin stock since the compressive end-load is directly proportional to the cube of thickness.

ASME Paper No. 60-SA-10, "Analysis of Buckling Column Spring with Pivoted Ends and Uniform Rectangular Cross Section," presented at the Summer-Annual Meeting, Dallas, Texas, June, 1960, 6 pp.

Theories of Fracture Under Combined Stresses

I. Cornet and R. C. Grassi, University of California, Berkeley, Calif.

Investigation of combined-stress fracture of materials ranging from relatively ductile nodular iron to brittle high-silicon iron. Data obtained from this study and from the pertinent literature are evaluated with respect to the various fracture theories.

Essentially, the stress system involved may be related to, or formulated in terms of, an average shearing stress acting on an infinitesimal volume in the body of the solid. The effect of structural factors may be summed in terms of a notch-concentration factor, K, based on hypothetical and fictitious cavities within and at the surface of the material. Equations may then be obtained which conform to the data available.

"A Study of Theories of Fracture Under Combined Stresses," presented at the ASME-AWS Metals Engineering Conference, Los Angeles, April, 1960, 8 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

Fourth Conference on Manufacturing Automation, collected papers available from *Automation*, Penton Publishing Co., Penton Bldg., Cleveland 3, Ohio, price 2 dollars.

The Institute of Machine Elements, Chalmers University of Technology, Gothenburg, Sweden.

The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London S.W. 1, England.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

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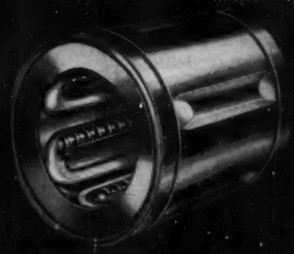

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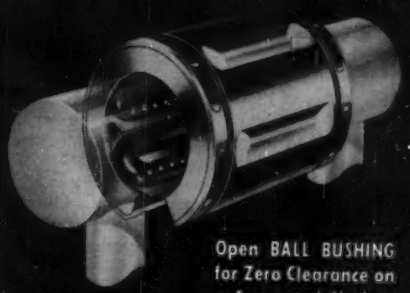

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Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Porous Metal

Porostrand, a new type of porous metal made by wire-winding techniques, is described in Bulletin BFD-180. Bulletin includes both filtration and nonfiltration applications of the porous metal. Typical applications are listed, together with outstanding features, including wide size range of finished structures. 2 pages. Bendix Aviation Corp., Bendix Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich.

Circle 681 on Page 19

Motor Controls

Form A-262, titled "½ the Size of Conventional Controls," describes RA magnetic motor controls and explains why this design offers reduced size and weight without sacrificing performance and dependability. Folder also provides explanations of technical and design features of RA starters and contactors. NEMA Sizes 0 through 5 are pictured, along with several enclosure types available. 6 pages. Arrow-Hart & Hegeman Electric Co., Industrial Control Div., 103 Hawthorn St., Hartford 6, Conn.

Circle 682 on Page 19

Fluid Drives

Class 4 line of adjustable-speed Gyrol fluid drives is described in Bulletin A-719. Principles of operation are discussed, and typical applications are shown. Horsepower and inertia starting-capacity curves are used for graphic presentation. Direct-reading selection-guide charts are presented for both variable-torque and constant-torque applications. Dimensional data are provided in tabular form, correlated with layout-type dimensional drawings. 20 pages. American-Standard, Industrial Div., Detroit 32, Mich.

Circle 683 on Page 19

Projector-Printer

Colorful bulletin, titled "A 34 x 48-Inch Print in 40 Seconds," describes the Kecofax projector-printer, an electrostatic system capable of making prints from 8½ x 11 to 34 x 48 in. from miniature negatives. Bulletin includes pictures, specifications, and information on operation. 4 pages. Keuffel & Esser Co., Third and Adams Streets, Hoboken, N. J.

Circle 684 on Page 19

O-Rings

Vix-Syn O-rings designed to withstand a wide range of temperatures and pressures to 3000 psi are described in new catalog. Tables provide information on O-ring sizes by uniform dash number, and corresponding back-up washer dimensions are given. Gaskets and washers for universal tube fittings are also included. 20 pages. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

Circle 685 on Page 19

Teflon-Insulated Wire

Teflon-insulated enameled wire, magnet wire, and ultrathin-wall instrument wire are described in Form 200. Catalog discusses properties of magnet wire, special constructions, packaging, and gives complete specifications and dimensional data on the products. 8 pages. Tensolite Insulated Wire Co. Inc., Mechtron Div., 1000 N. Division St., Peekskill, N. Y.

Circle 686 on Page 19

Corrosion-Resistant Fittings

Bulletin describes various types of fittings available, with specifications and drawings for each type. Materials available for each fitting are listed, and typical installations are shown. Also included is information on torque, and general information about soldering, welding, and silver brazing stainless steel. Table provides comparative data on tubing and IPS pipe schedules. 22 pages. Horace T. Potts Co., Erie Avenue & D Street, Philadelphia 34, Pa.

Circle 687 on Page 19

Photovoltaic Cells

Bulletin GEZ-3005 offers a complete description of photovoltaic cells available for applications where light is used to perform a control function. Bulletin offers graphic data on spectral sensitivity, exposure effect, temperature characteristics, current output, internal resistance, and other factors. Dimensions of all available cells, and typical circuits for single and multiple-cell applications, are included. 8 pages. General Electric Co., Schenectady 5, N. Y.

Circle 688 on Page 19

Tandem Cylinders

Form BT describes tandem cylinders with two pistons mounted on one common rod. Material on applications, features, and sizes is provided. 2 pages. Allenair Corp., 255 E. Second St., Mineola, N. Y.

Circle 689 on Page 19

Precious Metals

Gold, silver, and platinum-group metals in various solid, clad, and cored mill forms are described in Brochure GP-22, "Precious Metals for Industrial Applications." Brochure outlines sizes, compositions, and uses of solid and clad gold and silver strip, tubing, wire, brazing alloys, and waveguide tubing. Typical platinum and platinum-alloy clad-metal combinations are noted, along with basic specifications for sheet, strip, rod, wire, foil, and tubing. Information on platinum thermocouple wire, platinum-clad electrical contacts, rhodium plating solutions, and other platinum products is included. 6 pages. Texas Instruments Inc., Metals & Controls Div., General Plate Products Group, 34 Forest St., Attleboro, Mass.

Circle 690 on Page 19

Stepping Motor

Digimotor, a compact stepping motor and indexing device, is described in Bulletin G-360-1. Brochure is completely illustrated and gives information on high reliability and high torque-to-size ratio. Included are descriptions of unidirectional and bidirectional models, with and without detent. Also a complete torque chart, description of internal mechanism, and environmental specifications are provided. 4 pages. Ledex Inc., 123 Webster St., Dayton 2, Ohio.

Circle 691 on Page 19

Solenoid Valves

Catalog 444 lists various types of valves, and provides all information on materials used, sizes, pressures, and applications. Flow charts for liquids and compressible fluids are presented, as well as coil charts and information on optional features available. 40 pages. Atkomatic Valve Co. Inc., 545 W. Abbott St., Indianapolis 25, Ind.

Circle 692 on Page 19

Coaxial Connectors

TNC coaxial connectors are presented in two-color bulletin. Featured is a TNC functional diagram which graphically illustrates types and flow of connectors by various cable sizes. Also included is a comprehensive presentation on calibrated reliability, with accompanying graphs. 12 pages. Kings Electronics Co. Inc., 38 Marbledale Rd., Tuckahoe 7, N. Y.

Circle 693 on Page 19

Mercury-Plunger Relays

Catalog 17-C contains information on single, double, and triple-pole nontilting mercury-plunger relays. Units are pictured, and specifications are provided for all types. 16 pages. H-B Instrument Co., American & Bristol Streets, Philadelphia 40, Pa.

Circle 694 on Page 19

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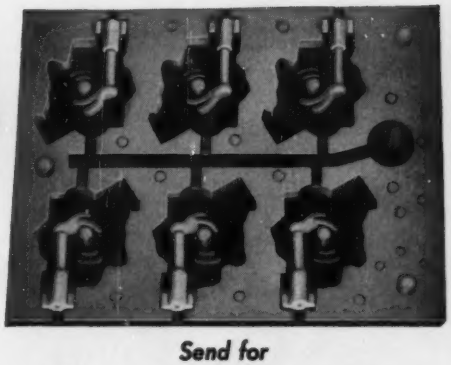
The Eaton process of Shell Coring in permanent mold and shell molded castings provides better internal surface finish and higher dimensional accuracy. Where more than ordinary quality and control of contour are required, the Eaton process offers distinct design advantages and greater uniformity in intricately cored sections.

EATON SHELL MOLDING



Eaton Shell Molding provides more closely controlled metallurgy and hardness for applications requiring pearlitic structures, close dimensional control, and complex designs and contours. Eaton Shell Mold Castings require less machining and finishing, with resulting savings in material, tooling, and shipping.

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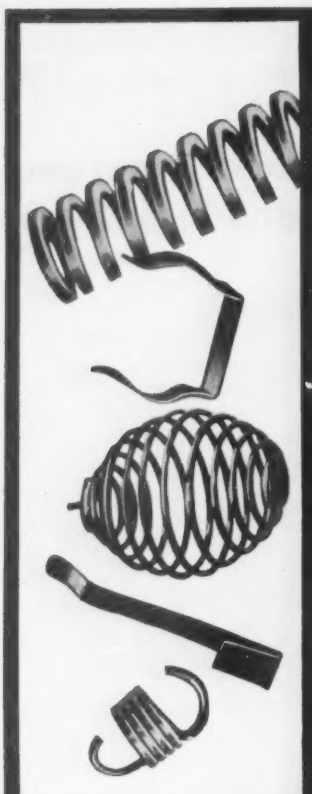

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...and now ISOLOY stainless steel spring wire—all from RIVERSIDE-ALLOY

Riverside-Alloy Metal is your *one* source of the world's finest, most uniform spring material . . . round or flat. And now, we add ISOLOY stainless steel!

Stainless is *not* a new material for Riverside-Alloy. But ISOLOY *is* a new trade name. The name ISOLOY was coined so that on specifications you can differentiate Riverside-Alloy stainless spring wire from wires made to conventional standards of uniformity. Regardless of test or comparison, ISOLOY exhibits uniform temper, dimensional size, grain size, tensile strength and coating.

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PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

Rotary Switch

Small, lightweight rotary switch which completes up to 100,000 contacts per minute with no bounce is described in two-color bulletin. Advantages of the unit are listed, in addition to all specifications and environmental characteristics. Complete parts breakdown is shown in a comprehensive exploded view. 4 pages. Genge Industries Inc., Circuit Controls Co. Div., 1500 F. Colorado St., Glendale 5, Calif.

Circle 695 on Page 19

Instrument Components

New booklet describing Apcor instrument drives, flexible shafts, geared adaptors, gear boxes, tachometers, actuators, and clutches. Detailed specifications are provided on 12-speed instrument drives and geared adaptors, plus single and double gear boxes. Flexible shaft and clutch assemblies are also described. 12 pages. Geartronics Corp., Actuator Products Div., Woburn, Mass.

Circle 696 on Page 19

Insulating Varnish

Form SV-116 presents properties and performance data on Isonel 31 modified-polyester insulating varnish. High heat resistance that makes varnish effective for Class F, B, or A equipment is illustrated in graphs and tables. Data on high bonding strength are conveniently summarized in graphs. Successful applications in various types and sizes of motors, transformers, and generators are illustrated pictorially. 6 pages. Schenectady Varnish Co. Inc., Schenectady 1, N. Y.

Circle 697 on Page 19

Rotary Pumps

Line of variable-capacity rotary pumps is described in Bulletin 600. Vari-Flo pumps permit "dialing" any desired flow rate, from zero to full capacity, without changing pump speed. Bulletin explains the principle of operation, and includes cutaway illustrations of four basic models. It also provides a guide to selection of Vari-Flo pumps, including an outline of selection procedures, application data tables, and performance curves. 8 pages. Blackmer Pump Co., Grand Rapids 9, Mich.

Circle 698 on Page 19

Electronic Component Parts

Complete technical data on electronic component parts — terminals, terminal boards and strips, banana jacks and plugs, and other parts for military and commercial precision products—is provided in new bulletin. Catalog also contains charts of basic information on typical values of laminates, including general physical and electrical properties of those used in manufacturing terminal boards and special fabricated parts. 36 pages. National Tel-Tronics Corp., 52 St. Casimir Ave., Yonkers, N. Y.

Circle 699 on Page 19

Impulse-Counting Devices

Revised general bulletin gives brief facts on each of the various impulse-counting devices in the Sodeco line. Described are electric-reset counters, manual-reset counters, monodecade counters, predetermining counters, short counters with pushbutton reset, hours-minutes-seconds indicators, printing counters, heavy-duty counters, and impulse transmitters. 4 pages. Landis & Gyr Inc., 45 W. 45th St., New York 36, N. Y.

Circle 700 on Page 19

Direct-Recording Oscillograph

New manual illustrates the versatility of Visicorder direct-recording oscillograph. Designed as a reference guide for engineers and scientists, booklet contains 18 case-history descriptions of how Visicorders have been used in widely different ways. 36 pages. Minneapolis-Honeywell Regulator Co., Heiland Div., 5200 E. Evans Ave., Denver, Colo.

Circle 701 on Page 19

Molded V-Belt

Design features and performance advantages of Type CX molded V-belts are detailed in Bulletin M220. Included are specifications for standard and nonstandard belt sizes, and a condensed, pre-engineered, CX V-belt drive-selection table for easy reference in determining the correct belt size for electric motor drives. 4 pages. Raybestos-Manhattan Inc., Manhattan Rubber Div., Passaic, N. J.

Circle 702 on Page 19

Variable Transformers

Line of "v.t." transformers for low-voltage applications such as transistorized power supplies and plating-bath power supplies is presented in Bulletin 151. Many types are shown, with information on sizes, output, and applications. An application selector chart presents data on single and three-phase units. 8 pages. Ohmite Mfg. Co., 3681 Howard St., Skokie, Ill.

Circle 703 on Page 19

Pushbutton Switches

Bulletin 7000 provides information on pushbutton switches, available in single and double-row assemblies of 4 to 12 stations, with interlocking action, illuminated or nonilluminated. Included are photographs, dimensional drawings, and detailed specifications. 4 pages. Donald P. Mossman Inc., Brewster, N. Y.

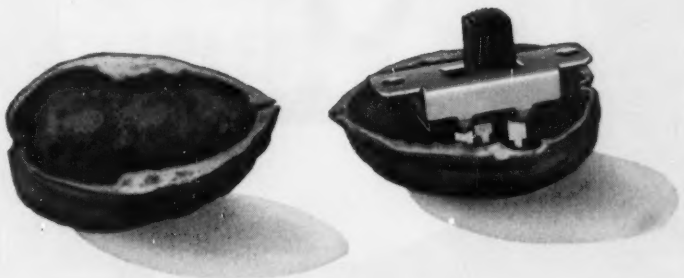
Circle 704 on Page 19

Air and Hydraulic Cylinder

Bulletin SQ-3-60 describes the Squair Head air and hydraulic cylinder. Literature gives specific technical information on available bore sizes, rod dimensions, and allowable strokes. Large cutaway drawing shows important features. 16 pages. Tomkins-Johnson Co., Jackson, Mich.

Circle 705 on Page 19

6-amp jobs for low cost slide switches as small...



as 3-amp and 1-amp Stackpole Slide Switches

With dependable switches such as this 6-ampere Type SS-36-1 you can often make cost savings up to 50% over conventional appliance switches . . . and improve the convenience and styling of your electrical products in the bargain!

New Stackpole SS-36-1 is but one of 15 standard types with U.L.I. ratings from 0.5 to 6 ampere that cover practically any needed switching arrangement from SP-ST to 4-position, multi-pole. And trigger knobs in 10 attractive colors add real decorative appeal.

Write for Bulletin RC-12D for full details on today's most complete line of versatile slide switches and accessories.

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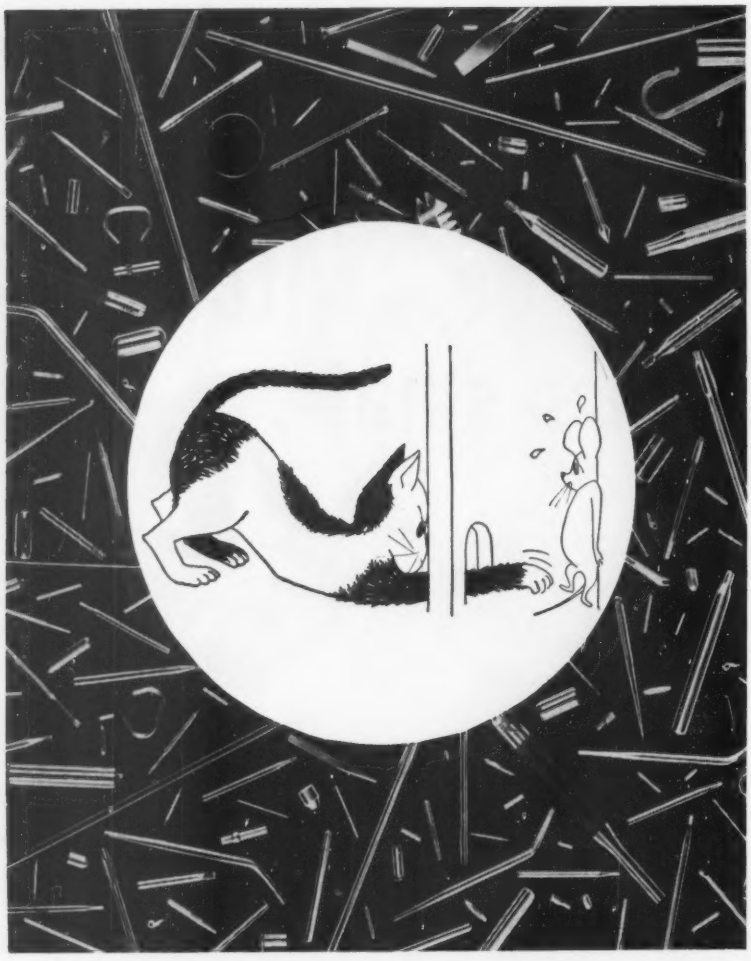
Circle 526 on Page 19



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Electromechanical Components

Short-form Catalog SE-60 covers principal lines of LVDTs, RVDTs, transducers, and accelerometers for use in measuring, indicating, recording, and control applications. In addition to mechanical and electrical specifications, brochure also includes application diagrams and performance curves. 4 pages. Schaevitz Engineering, P. O. Box 505, Camden 1, N. J.

Circle 706 on Page 19

Welded Steel Tubing

New technical bulletin contains a quick-reference weight chart for square and rectangular welded steel tubing. In addition to the large, easily readable weight chart, bulletin contains a comprehensive listing of square and rectangular welded tubing tolerances for twist, straightness, cutting length, corner radii, and diagonal dimensions. 4 pages. Standard Tube Co., 24400 Plymouth Rd., Detroit 39, Mich.

Circle 707 on Page 19

Machining of Teflon

Form 0701, titled "Basics in the Machining of Teflon," contains suggestions for stress relieving; tools and coolants to use; speeds and rates of feed; rakes, angles, and clearances; and burrs and chips. Other information includes turning, boring, drilling, tapping, reaming, counterboring, and grinding; fly-cutting; surface finishes; and tolerances. 12 pages. Raybestos-Manhattan Inc., Plastics Products Div., Manheim, Pa.

Circle 708 on Page 19

Stock and Special Gears

New brochure shows and describes a complete line of stock and special gears which meet all industrial power-drive requirements. Both 14½ and 20-deg pressure-angle styles are included. Literature contains information on bevel, helical, miter, worm, and spur gears, as well as steel racks. It stresses the ready availability of these gears from local supply areas. 4 pages. Ohio Gear Co., 1200 E. 179th St., Cleveland 10, Ohio.

Circle 709 on Page 19

Electrical Meters and Accessories

Available for military and commercial use in a variety of applications, electrical meters and accessories are discussed in Bulletin 81100. Various meters are pictured, and tables provide full specifications. Special meters are also described. 8 pages. WacLine, 35 S. St. Clair St., Dayton 2, Ohio.

Circle 710 on Page 19

Motor Application Guide

New 1960 Motor Application Guide, Bulletin 270B, outlines Century motor characteristics and includes up-to-date information on motor designs, including all specifications. 16 pages. Century Electric Co., 1806 Pine St., St. Louis 3, Mo.

Circle 711 on Page 19

Pneumatic Instruments

Pneumatic instruments for the process industries are described in Catalog 515. Pressure and temperature pilots and pneumatic transmitters are featured; pilot specifications are listed and control actions are described. Photographs highlight mechanical construction features of both types of instruments, and diagrams show case dimensions and mounting arrangements. Catalog includes detailed information on measuring elements for use with both types. All information on ordering is included. 12 pages. American Machine & Metals Inc., U. S. Gauge Div., Sellersville, Pa.

Circle 712 on Page 19

Miniature Strain Gages

Line of subminiature, free-filament wire strain gages, designed for accurate strain measurement on any test surface or material in a wide variety of applications, is discussed in Product Data Sheet 4330. Brochure contains line drawings, graphs, and tables to support the data and specifications concerning Type HT gage. 4 pages. Baldwin - Lima - Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.

Circle 713 on Page 19

Rotary Pump Selection

Rotary pump selection manual presents technical data in an easy-to-understand way. Liquids are grouped into eight classifications according to viscosity, and each classification has its own selection table. Table makes it possible to make a fast rotary-pump selection by matching liquid to pump. Tables of selection cover almost all liquids from alcohol to heavy asphalts. Information on operating limits is also provided. 18 pages. Deming Co., Salem, Ohio.

Circle 714 on Page 19

Switch-Circuit Assemblies

Preliminary Data Sheet 172 provides information on synchronized "one-shot" switch-circuit assemblies for use in pulse and digital systems. Application information is listed, as well as price list and descriptions of various units. Typical output-pulse curves are shown. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill.

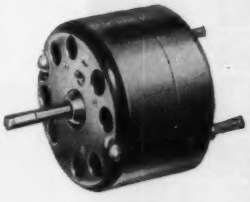
Circle 715 on Page 19

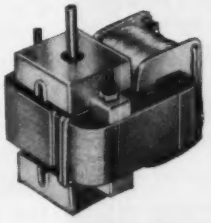
Small-Size Cylinders

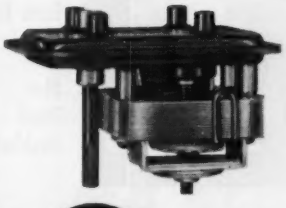
Form 360 contains full-size tracing templates, accurate to the width of a pencil line, of a complete line of small-size cylinders. Cylinders are available in medium and high-pressure series. Capacity chart lists push and pull forces at various pressures for the three bore sizes. Chart lists maximum recommended strokes for various mountings. Folder also includes price list and weight chart. 16 pages. Control Line Equipment, 19560 Center Ridge Rd., Cleveland 16, Ohio.

Circle 716 on Page 19

...that's why quality and economy go hand-in-hand in famous GI motors







True economy in any manufactured product is achieved by more efficient production, not by the use of cheaper components. In General Industries' plants, we produce practically every component of GI motors except the raw materials. Our self-sufficient, integrated production lines, employing the most modern machinery, permit us to offer you quality and economy unexcelled in the A.C. motor field. Add our 40 years' experience in designing and building motors for every requirement, and you can readily see why leading manufacturers the world over prefer to Specify GI!

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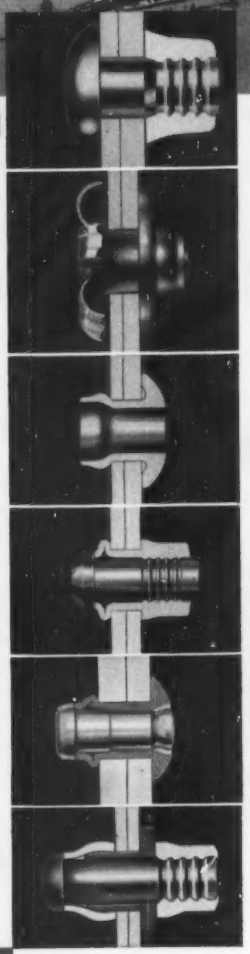
Circle 528 on Page 19

● GREATER STRENGTH
● UNIFORM TENSION
● MAXIMUM SHEAR STRENGTH
● PRECISION FIT
● LOWER INSTALLED COST

Huck permanent fasteners are available in many types, shapes and sizes, from 1/8" to 3/4" diameter, to meet the requirements of all types of manufacturing, from railroad cars, trailers, buses, ships, blowers, appliances, to farm equipment and prefab buildings. These and many other users specify Huck fasteners for reasons of economy, speed of application, strength and dependability. You too, may find the answer to faster, better, cost-cutting assembly by investigating Huck's advantages. Write for literature, or ask for a Huck Sales Engineer who will be glad to explain the advantages of Huck Fasteners in your product. No obligation.



CL— Commercial Huckbolt

DR— Daisy Blind Rivet

PT— Pull-Thru Blind Rivet

OS— Oversize Structural Blind Rivet

MLS — Mechanical Lock Spindle Blind Rivet

BL— Blind Huckbolt

HUCK MANUFACTURING COMPANY
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HELPFUL LITERATURE

Welding Equipment

Revised edition of catalog on a complete line of manual, semiautomatic, and automatic Heliwelding equipment is now available. Form ADC 709G contains information on accessory equipment, tungsten electrodes, and filler wires used in conjunction with the welding process. Data on two new manual Heliweld holders are included. Also present are two new automatic heads, and Helicraft 100 kit. 24 pages. Air Reduction Co. Inc., Air Reduction Sales Co. Div., 150 E. 42nd St., New York 17, N. Y.

Circle 717 on Page 19

Heated Gages and Valves

Data Unit 363 gives detailed information on heated gages and valves which have wide application where liquids must be kept at higher than ambient temperatures for process reasons, or to hasten speed of response to level changes. They are also for use in outside applications to prevent breakage of gages from freezing. Pictures, line drawings, and cutaways provide details and specifications. 4 pages. Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

Circle 718 on Page 19

Potentiometers

Trimpot and Trimit leadscrew-actuated potentiometers are described in Specification Summary 5. Designed for quick reference, brochure summarizes key information on sixteen standard models including resistances, terminal types, power ratings, operating temperatures, and dimensions. Cutaway drawings of Models 200, 220, and 224 illustrate the internal construction and show outstanding design features. 4 pages. Bourns Inc., 6135 Magnolia Ave., Riverside, Calif.

Circle 719 on Page 19

Industrial Hose

New catalog details manufacturing facilities and complete line of industrial hose now available. Types of hose described include air, water, polypurpose agricultural spray, welding, paint spray, booster, and farm tank. Pertinent information on applications, cover, reinforcement, tube, lengths, packaging, and recommended couplings is outlined with each hose illustration. Reference section illustrating and describing various types of industrial-hose couplings is also included. 30 pages. Swan Rubber Co., Bucyrus, Ohio.

Circle 720 on Page 19

Portable Testing Machines

Bulletin 60-A describes testing machines for tension, shear, and compression of metals, plastics, rubber, adhesives, and ceramics. Units have 0 to 10,000-lb capacities. Two models are shown, with features listed and specifications provided. 4 pages. Research Products Co., P. O. Box 1047, 1415 Third St. S, St. Petersburg 31, Fla.

Circle 721 on Page 19

Sensing and Measuring Devices

New general catalog, Bulletin 1308, provides design details and application of pressure instrumentation, force-balance instruments, unbonded strain-gage and potentiometer pressure transducers, vibration transducers, accelerometers, galvanometers, and ceramic and precision optical products. Pictures and specifications are provided. 16 pages. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

Circle 722 on Page 19

Hydraulic Pump

New brochure describes and illustrates AP10V axial-piston, variable-volume pump design with pressure compensator control. A cutaway drawing is provided, and tables present information on specifications and engineering data. Features and applications are listed. 4 pages. American Brake Shoe Co., Dept. A, 530 Fifth Ave., New York 36, N. Y.

Circle 723 on Page 19

Powdered Polyethylene

"Microthene—Polyethylene in Powder Form," explains in detail how finely divided or powdered polyethylene is designed for a number of applications where conventional polyethylene resins cannot be employed. Booklet presents information on sizes, fields of application, and techniques for using the material. Booklet also presents the various grades of Microthene which are available. National Distillers & Chemical Corp., U. S. Industrial Chemicals Co. Div., 99 Park Ave., New York 16, N. Y.

Circle 724 on Page 19

Perforated Metal

Brochure 8159 provides engineering data for complete specification of heavy-gage perforated metal. Data include applications of perforated metal, directions for pattern specification, dimensions, unit weights, calculation of open area, materials selection, fastening methods, and equivalence tables relating wire cloth to square, round, and Hexcreen patterns. 40 pages. Cross Perforated Metals, National-Standard Co., Niles, Mich.

Circle 725 on Page 19

Thin-Sectioned Ball Bearings

New concepts for applying thin-sectioned large-bore ball bearings to equipment designs are presented in a new engineering booklet, Bulletin S 112R, titled "Selected Engineering Drawings for Mounting Reali-Slim Bearings." Installation drawings illustrate how the bearings save weight, space, and cost. Pictured are 23 drawings of applications, including transmissions, machine tools, manufacturing and assembly machines, control equipment, instrument mounts, and clutches. Booklet includes specifications and prices for the radial CP Reali-Slim bearings. 28 pages. Write on company letterhead to Kaydon Engineering Corp., McCracken St., Muskegon, Mich.

NEEDED:
VIBRATION ISOLATION
AT BOTH HIGH AND
LOW FREQUENCIES

A mount soft enough to isolate vibration in the upper range of frequencies generally gives trouble with a low natural frequency. With sensitive precision equipment, such as airborne sighting mechanisms, for example, a mount must work at *both* ends of the frequency spectrum.

ANSWER:
MB ISO-DAMP (tm) MOUNTS
CONTROL FULL
FREQUENCY RANGE

Resilient rubber sections with equal spring rates in all directions (an original MB mount principle) give the MB Isomode Mount its high frequency isolation efficiency in any position. In the low range, a unique damping mechanism effectively restricts resonant build-up; does not affect high frequency isolation. Unit also meets MIL-E-5272-A shock requirements.

WHAT'S YOUR
MOUNT PROBLEM?

Iso-Damp mounts can be modified to meet your particular requirements. Or possibly one of MB's other standard mounts may be the answer to your special vibration control problem. Why not let MB's experienced specialists help find the right answer for you. Write us for complete information—ask for Bulletin 418-4.

MB ELECTRONICS
A DIVISION OF TEXTRON ELECTRONICS, INC.
1056 State Street, New Haven 11, Conn.

Circle 530 on Page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Tapping Screw

for assembly of light-gage metal parts

Improved hole-drilling tapping screw, called Tapits, drills its own hole and forms its own thread. It also has an integral washer with a serrated face that acts as a built-in brake to minimize stripping and spinning. All sizes of Tapits, from No. 6 to No. 10, have the same size hex head. Pyramid-type point

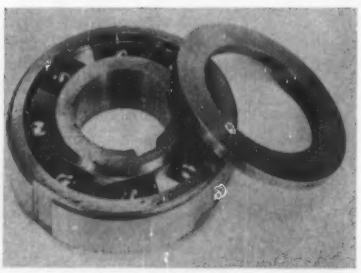
starts drilling immediately, will not walk, skid, or creep. **Parker-Kalon, Div., General American Transportation Corp.**, Clifton, N. J.

Circle 726 on Page 19

Ball Clutch and Back Stop

has balls used as power-transmission members

Ball clutch-back stop is available in shaft sizes of 1/8 to 1 1/2-in. diam with special sizes to 5-in. diam available on special order. Balls are employed as power transmission members rather than cams or sprags. When free-wheeling, balls have a spinning and rolling motion as contrasted with other clutches which always depend on the same surface to transmit the load. Feature results in long accurate operation and a minimum free-wheeling drag. External dimensions of the clutch are



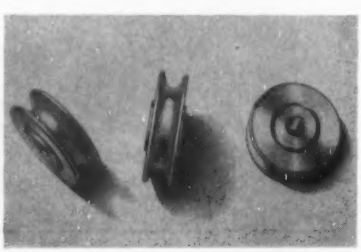
the same as standard ball bearings and allow for its incorporation into most types of power-transmission equipment with a minimum of difficulty. Eight models are available with normal torque from 0.5 to 3200 lb-in. **Odin Corp.**, Castleton, Ind.

Circle 727 on Page 19

Ball-Bearing Pulleys

handle cable sizes to 1/4-in. diam

Low-cost ball-bearing pulleys, for use with rope, wire rope, or cable, are available in six standard sizes from stock. Pulleys handle cable sizes to 1/4-in. diam, have ODs of 7/8 to 2 in. and bores from 3/16 to 3/8 in. Bearing rings are case-hardened steel to provide high load capacity and cable-groove wear resistance. Precision steel balls, operating in unground raceways, provide free turning at low cost. Units are cadmium plated for corrosion resistance. Grooves are tapered and rounded to accommodate considerable latitude in cable or rope di-



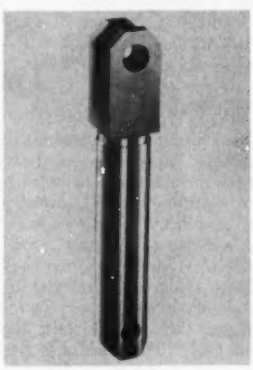
ameter. Hardened, tapered grooves and low bearing friction ensure minimum cable slippage and groove wear. **Syracuse Bearing Co.**, 428 E. Jefferson St., Syracuse, N. Y.

Circle 728 on Page 19

Tension Liquid Spring

can be preloaded to 300 lb with end force of 800 lb

Model T823 tension liquid spring using liquid compressibility has a 1/2-in. stroke, is 1 in. in diam by 3 in. long (plus mounting ends). It can be preloaded to 300 lb with an end force of 800 lb. As a shock absorber, spring absorbs up to 1000 lb-in. of energy. Complete with end attachments, liquid spring equals



five coil springs of the same dimensions. **Taylor Devices Inc.**, 188 Main St., North Tonawanda, N. Y.

Circle 729 on Page 19

Sleeve Valve

for air control can be mounted in any position

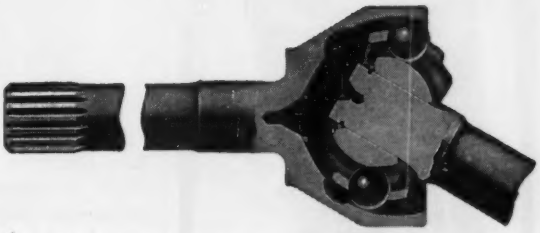
Three-way, two-position air-control sleeve valve has applications where controlling single-acting, spring-return cylinders automatically speeds production. Valve, 2 3/4 in. long x 1 1/8 in. diam, can be installed quickly and easily in any position and in

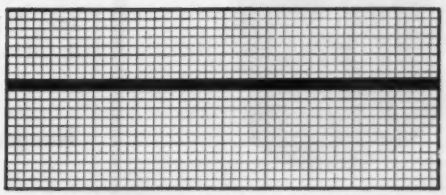
RZEPPA Universal Joints Transmit Torque Smoothly—*Even At High Angles!*

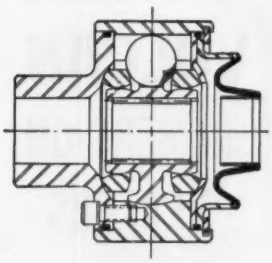
Rzeppa universal joints transmit 100% precision-smooth torque continuously—at angles of 35° and higher! Constant velocity action completely eliminates chatter, roughness and vibration. Size for size, you get longer shaft and bearing life, higher torque capacity with Rzeppa joints than with any other type!

The secret of Rzeppa's uniform power flow is that the driving balls are always in the bisecting plane of the driving and driven shafts. No matter what the shaft angle, torque flows evenly at constant velocity.

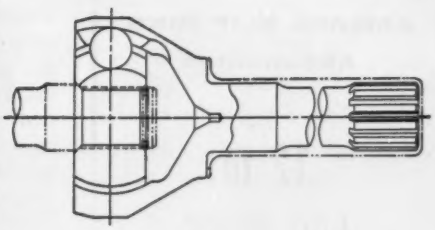
Rzeppa constant velocity joints are available in a wide variety of sizes, styles, angles and speeds. Rzeppa joints have been used successfully in equipment ranging from giant road-building and mining equipment to the most intricate aircraft and missile applications.



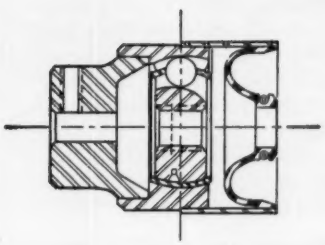




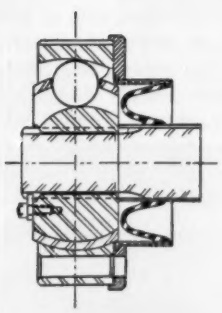
"MX" Type CV Joint (⅞" to 3½" swing diameter) . . . designed primarily for high speeds, low angles . . . blowers • compressors • servo motors • pumps • control devices • frequency converters • missiles • aircraft • dynamotors



Bell-Type CV Joint (15/16" to 2½" axle shaft diameters) . . . designed for high-angle driving steering axles used in road building machinery • mining machinery • industrial • automotive applications



"OV" Type CV Joint (2⅛" maximum swing diameter) . . . designed for smaller applications . . . ordnance • machine tools • servo mechanism • farm equipment • automotive equipment



Disc-Type CV Joint (from 2⅛" to 16¼" swing diameter) . . . designed for all types of industrial drive applications where constant velocity and trouble-free service are required.

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Company_____

Street_____

City_____ State_____

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CON-VEL DIVISION

DANA CORPORATION

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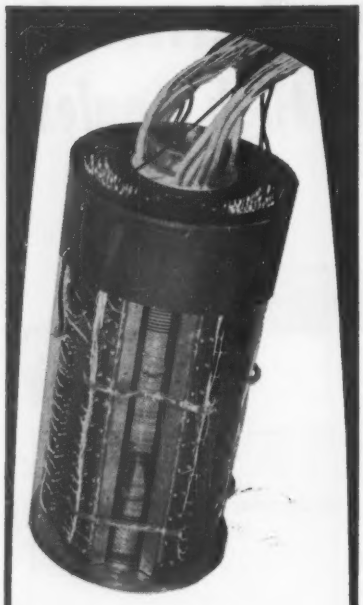
Detroit 11, Michigan

Circle 531 on Page 19



NEW SERIES of Antenna SLIP RING Assemblies

12 to 500 RINGS

A standardized line of large Slip Ring assemblies, designed for a multiplicity of instrumentation, control and power circuit applications. First production assemblies are in use on radio telescopes, radar and tracking antennas and human centrifuge installations.

Assemblies vary from 12" to 72" in length, are either shaft or flange ball-bearing mounted and may be specified with hermetically sealed housings. Noise levels are held to a minimum. So are intercircuit losses, cross-talk and radiation, through proper shielding.

For complete information, write:

SCA

SLIP RING COMPANY of AMERICA

3612 West Jefferson Blvd., Los Angeles 16, Calif.

Circle 532 on Page 19

any place on the production line. Eight air-passage holes allow valve to operate close to full capacity with very low friction loss. **Airmatic Valve Inc.**, 7313 Associate Ave., Cleveland 9, Ohio.

Circle 730 on Page 19

Manganese Battery

gives long life at high or low drain

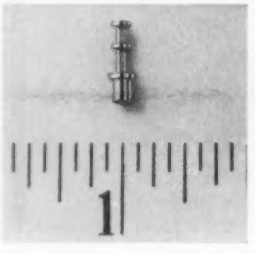
Alkaline manganese dry cell, an all-purpose battery, gives exceptionally long life both in high and low drain service. Shelf life is at least two years without serious loss of capacity. The AA size delivers up to 1800 ma-hr on continuous low drain service, and approximately 2000 ma-hr at intermittent low drain. On a 5-ohm load it will deliver about 1000 ma-hr. Discharge voltage is considerably steadier than conventional types, and double-steel case construction effectively eliminates leakage. Battery is priced between conventional (zinc-carbon) and mercury batteries of identical size. **Mallory Battery Co.**, 13000 Athens Ave., Cleveland 7, Ohio.

Circle 731 on Page 19

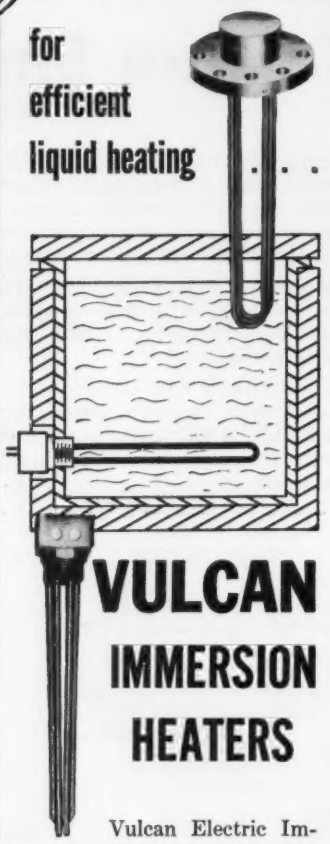
Solder Terminal

for mounting in panels from 1/16 to 5/32 in. thick

Cambion solder terminal, No. 1026, has a double turret and mounts in a 0.094-in. hole (0.237 in. high when mounted). Width of terminal



for efficient liquid heating . . .



VULCAN IMMERSION HEATERS

Vulcan Electric Immersion Heaters are highly efficient because they are immersed directly in the material to be heated. They are ideal for the heating of all types of liquids — water, oil, wax, paraffin, asphalt, tars, etc., in tanks, boilers, urns, kettles, and other containers.

Heaters are available with flange or threaded bushings; bayonet type, side or bottom outlet; copper, steel, stainless, or alloy sheath; single or three phase; readily adaptable to thermostatic control within close tolerances; full range of wattage and voltage ratings; pressures up to 3500 psi.

Write for catalog and prices.

VULCAN

Versatility in Electric Heating

VULCAN ELECTRIC COMPANY, Danvers, Mass.

Circle 533 on Page 19

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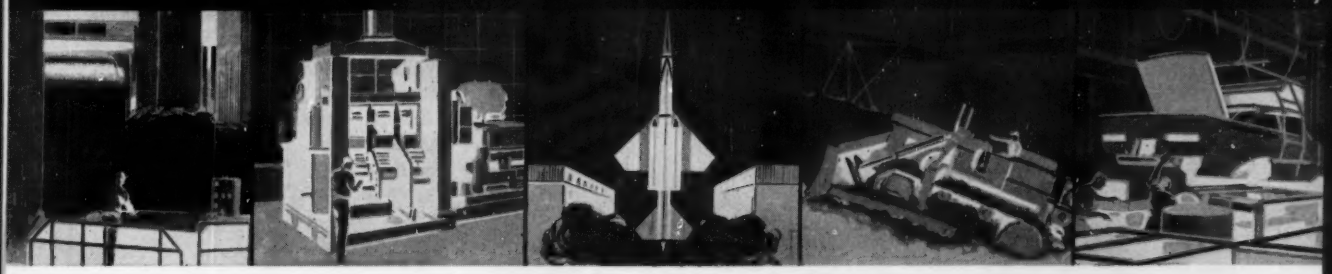
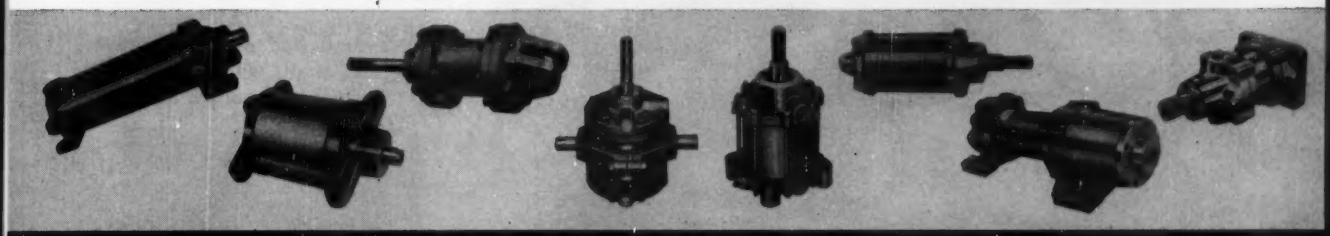
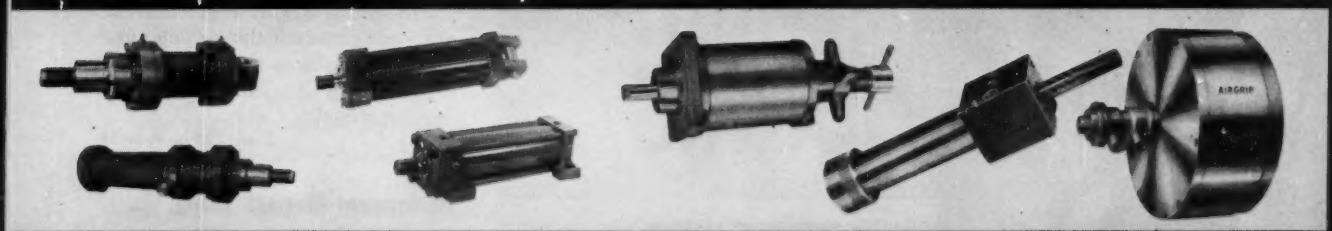


Select your needs

from the World's Widest Selection of Standard Cylinders



Check these compelling reasons why Anker-Holth air and hydraulic power cylinders save you time, trouble and money – widest selection of standard models | reliability through military accepted quality control program | simplified maintenance | all mountings available | bores 1" to 30" | strokes to 40' | built to JIC specifications | nationwide engineering service on call | complete facilities to engineer any power cylinder application outside the standard model.



Only a few models could be shown above

This free catalog shows them all

ANKER HOLTH

DIVISION, THE McDOWELL-WELLMAN COMPANIES

Circle 534 on Page 19

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THE WELLMAN ENGINEERING COMPANY
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Company_____

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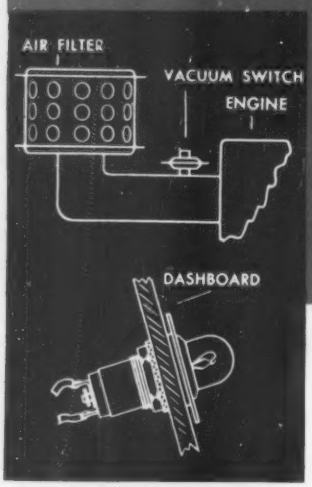
another fine product by

McQUAY-NORRIS



System consists of sensitive vacuum switch and dashboard warning light. Can be mounted in any position on the filter with ⅛" male threaded pipe boss. Operates in all temperatures up to 250° F. and can be adjusted within vacuum range 5 to 30 inches water. For both carbureted and non-carbureted engines.

Your inquiries are invited!

McQUAY-NORRIS MANUFACTURING CO.
ELECTRIC PRODUCTS DIVISION
3260 Brannon Ave., St. Louis 39, Missouri

50 YEARS IN THE MANUFACTURE OF PRECISION PRODUCTS

shoulder is 0.125 in. diam. Terminal is brass per QQ-B-626a, Comp. 22, ½ hard. It is finished with 0.0003-in. silver plate plus water-dip lacquer. Terminal, which conforms with specifications of NAS 705, is available with shank lengths for mounting in panels from 1/16 to 5/32 in. thick. **Cambridge Thermionic Corp.**, 445 Concord Ave., Cambridge 38, Mass.

Circle 732 on Page 19

Zippered Tubing

of stainless steel for shielding cables and wires

Stainless-steel Zippertubing is available for shielding and jacketing cables and wires that are subject to extreme punishment. Material offers positive protection against abrasive forces that would cut other materials. Tubing is furnished in solid

sheet or strip form and can be made into tubing on the job without the use of special dies, guides, rollers, or other equipment. Tubing shields and jackets cable in a single operation. **Zippertubing Co.**, 752 S. San Pedro St., Los Angeles, Calif.

Circle 733 on Page 19

Permanent-Magnet Alloy

can be formed in a wide variety of shapes

Cunife copper-nickel-iron permanent-magnet alloy possesses high coercive force and energy product values, as well as excellent ductility, malleability, and machinability. It has greater uniformity than that previously associated with similar permanent-magnet alloys. It can be stamped, machined, or otherwise formed readily by conventional methods into a wide variety of com-

Circle 535 on Page 19

Circle 536 on Page 19→

working with

Du Pont Zytel®

one of Du Pont's versatile engineering materials

Revolutionary advance in rifle making . . .

Remington Nylon 66 of structural Du Pont ZYTEL®

Remington's history-making design uses Du Pont ZYTEL nylon resin—here's the first rifle ever to be made with a structural-nylon stock!

ZYTEL is one of the toughest, most durable organic materials known. The stock is chip-proof, waterproof, oilproof. ZYTEL nylon is light in weight, too . . . the new gunstocks have 1/5 the weight of wooden stocks with no loss in ruggedness. Even when soaked in water, these stocks will not warp. There's no need for lubrication. ZYTEL permits complete integration of stock, receiver and barrel . . . allows tolerances that deliver the most trouble-free autoloading 22 action ever known. The stability of ZYTEL makes it possible to use three-point micro-bedding of the barrel for match-rifle accuracy at moderate cost. ZYTEL is heat-resistant. Hours of steady firing have no effect on the stock. The moldability of ZYTEL insures perfect 16-to-the-inch checkering. The colorability of ZYTEL ushers in a new era in stock design. The new Nylon 66 comes in two distinctive colors, Seneca green and Mohawk brown.

The strength, durability, abrasion resistance, low-friction properties of ZYTEL offer you many possibilities when you design a new product or component, or wish to simplify and update an existing product. On the following page are more examples to suggest profitable design improvements for *your* products.

NEW REMINGTON 22 is the first rifle with a structural-nylon stock. Made of Du Pont ZYTEL nylon resin, the stock is light in weight and durable under all field conditions. (Nylon 66 autoloading 22 rifle manufactured by Remington Arms Company, Inc., Bridgeport 2, Connecticut.)

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BETTER THINGS FOR BETTER LIVING

. . . THROUGH CHEMISTRY

working with

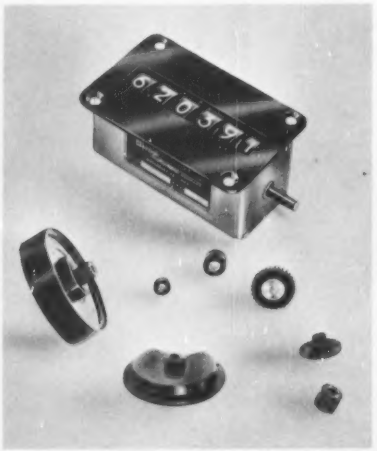
Du Pont Zytel®

nylon resins

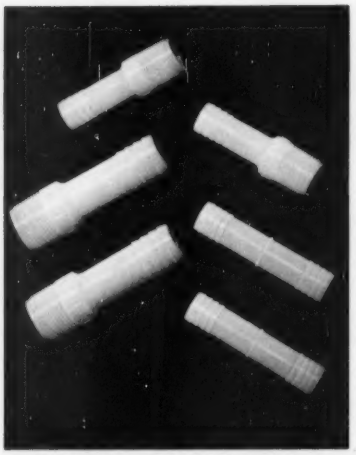
one of Du Pont's versatile engineering materials

Outstanding properties of ZYTEL® vital to many improved designs

ELECTRICAL LIMIT SWITCH made with 7 parts of ZYTEL lasts at least 5 times as long as former switches made with metal or other plastic components. The low friction and wear of ZYTEL enabled parts to hold to required dimensions after 65,000,000 test cycles, and the high arc resistance of ZYTEL prevents arc tracking. (Limit switch is molded by Berea Plastics Co., Berea, Ohio, for R. B. Denison Mfg. Co., Bedford, Ohio.)



COUNTER for instruments such as clocks and high-speed money counter uses drums, gears and other components molded of ZYTEL. Reasons: ZYTEL can be molded to close tolerances, and it offers the abrasion resistance and high fatigue endurance required for long, trouble-free service. (Molded by B & B Plastics, Inc., Oakville, Connecticut, for Haydon Instrument Company, Waterbury, Connecticut.)



PIPE FITTINGS molded of ZYTEL are used to connect plastic pipe with plastic or metal pipe. Pressure grooving and threads are molded into complex hollow shapes. Toughness and resistance to corrosion are typical of the properties you get with ZYTEL. (By Nylon Molded Products Corp., Garrettsville, Ohio.)

In addition to excellent electrical properties and resistance to corrosion, the mechanical properties of ZYTEL nylon resins usually give longer wear, even when subject to abrasion, impact or temperature extremes.

Du Pont ZYTEL may well help you save money by reducing production costs and giving improved performance under adverse conditions. Find out how by filling out and sending in the coupon below.

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. . . THROUGH CHEMISTRY

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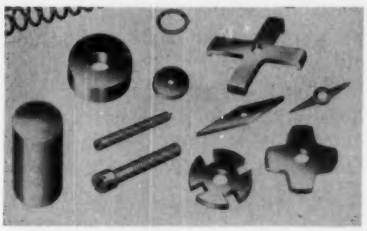
In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

ZYTEL® *nylon resins*
one of Du Pont's versatile engineering materials

Alathon® · Delrin® · Lucite®



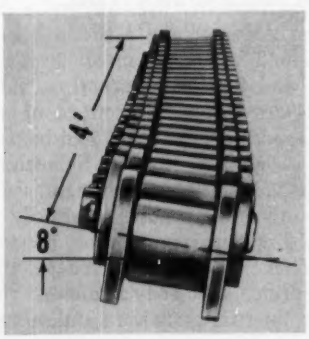
plex, intricately shaped parts which require no costly finishing operations. Alloy is suited for use in a broad range of applications requiring close tolerance parts with strong directional magnetic properties. It is available as finished magnets formed or fabricated to meet specific design and application requirements. It is also offered as wire and strip in an extended range of sizes, shapes, and widths. **Hoskins Mfg. Co.**, 4445 Lawton Ave., Detroit 8, Mich.

Circle 734 on Page 19

Roller Chain

has extra clearance between linkplates, pins, and bushings

Tuf-Flex roller chain incorporates engineering features that provide extra durability and flexibility to meet service demands of heavy construction and industrial machinery. Extra clearance between linkplates and between pins and bushings permits up to 4-in. lateral displacement and 8-deg twist for each 4 ft of chain to accommodate sprocket misalignment. Extra clearance also reduces stiffness after periods of idleness and exposure to mud, dirt, and weather. Straight linkplates transmit loads in a straight line to provide greater load capacity and withstand higher shock and peak loading. Chain is available in four pitch sizes which meet both military and ASA specifications and



←*Circle 536 on Page 19*

ACME'S
FINISHED BORE SPROCKETS
SAVE TIME AND MONEY

Choice of 99 sprocket sizes obtainable in single widths from 3/8" to 1" pitch exclusively.

Marked for easy identification.

Complete with standard keyways and set screws.

433 different bores, all completely machined.

No reboring required.

Immediate delivery from factory or distributors' stocks.

A terrific saving in time and money . . . reduces downtime . . . reduces maintenance cost

ACME finished sprockets are stocked in single widths from 3/8" to 1" pitch inclusive. 99 Sprocket tooth sizes with more than 433 different bores provide a wide selection range.

All finished bores are completely machined. Bores are accurately finished and are concentric to sprocket pitch and bottom diameters within A.S.A. standards.

ACME also carries a complete line of sprockets such as Grip-Master and Stock Sprockets.

Call your nearest ACME CHAIN Distributor. He has the full cooperation of our Engineering Department.

Write Dept. 6-E for new 100-page illustrated technical catalog including new engineering section showing 36 methods of chain adjustments.

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HOLYOKE MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

Circle 537 on Page 19

Less than .005" Runout on a 24" Shaft...

Holtzer-Cabot Solves Fractional H.P. Motor Problems

Holding runout tolerances on a motor shaft extending 24" beyond the motor frame poses a difficult design problem. To reduce runout, many manufacturers have resorted to complicated and expensive outboard bearings and shaft supports. To avoid this problem, one such company* came to Holtzer-Cabot, which in cooperation with the company's engineers, developed a motor with a special extended end cap and a heavier shaft. The result: less than .005 runout at one inch from the end of the 24" shaft.

Write for Information! Holtzer-Cabot specializes in the design and manufacture of fractional horsepower motors for all types of applications. For complete details on Holtzer-Cabot motors for specific applications, and a copy of "Key Factors in Selecting AC Motors for Instrument Service" write direct or use Readers Service Card.

**Name on request*

HOLTZER-CABOT ESTABLISHED 1875 NP

HOLTZER-CABOT

MOTOR DIVISION

National Pneumatic Co., Inc., Boston 19, Mass.

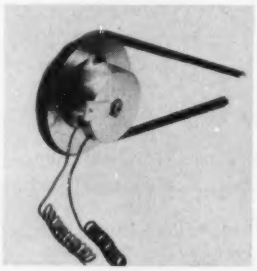
permit installation on sprockets cut for offset sidebar chain and standard roller chain. Offset connecting links can be installed easily and quickly because a drive fit is required through only one linkplate. **Diamond Chain Co.**, 402 Kentucky Ave., Indianapolis 7, Ind.

Circle 735 on Page 19

Miniature Positive Clutch

has magnetically engaged positive-acting crown teeth

No. CT14 miniature positive clutch is designed for instrument applications where a minimum space is available for the clutch. Positive-acting crown teeth are magnetically engaged and spring-released. Teeth are pitched for easy engagement at



very low rpm, and then smooth acceleration drives the load. Clutch is $1\frac{1}{2}$ in. in diam and over-all length is $\frac{3}{4}$ in. It develops 80 oz-in. torque and may be wound for 28 v dc. Sheave can be mounted easily on the driven hub which also serves as an armature. Other types of mountings are with worm and spur gears. **Stearns Electric Corp.**, 120 N. Broadway, Milwaukee 2, Wis.

Circle 736 on Page 19

Solenoid Valve

is three-way directional-control unit

Large capacity three-way valve has been added to the A Series line of solenoid valves. Available in 3/32, $\frac{1}{8}$, and 5/32-in. orifice sizes, valve provides directional control of air, oil, and inert gases, and can be used on vacuum down to 5 microns. Compact and light in weight, valve mounts in any position directly to the line and operates on pressure differentials to 250 psi, depending on orifice size. Body is die-cast zinc and internal parts are stainless steel

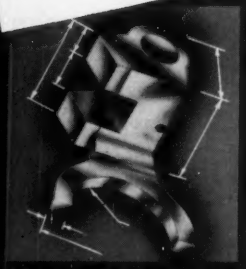
Circle 538 on Page 19

BUNTING® BEARINGS

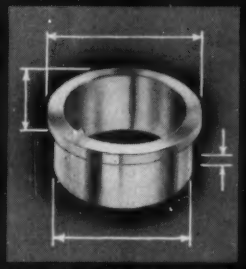
engineering for **both** cost and mechanical requirements in the bearing field . . .

Bunting can help you identify and procure the bearing or part that will do your job at the lowest possible cost. Often a re-examination of the actual mechanical needs of a bearing application reveals an opportunity to save money in design. Another saving is almost invariably achieved by considering ALL the new bearing materials which Bunting makes available to you today. Let Bunting help you engineer your bearing application in the light of modern availabilities. Send in your blueprints or ask for engineering counsel.

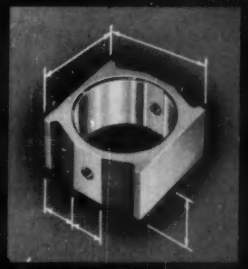
...case in point*



*Clearly evident is the economy in the production of this shifter fork by Bunting Powder Metallurgy. The elimination of machine work effects striking cost reduction.



*This cylinder gland bearing made of Bunting Bearing Aluminum is an example of how to save weight and money on the cost of large, thick-wall bearings and parts.



*This cast bronze cam block, made to unusually close limits with very fine finish, is absolutely round and true to size with cost at a feasible figure.

*Solid cast aluminum gear bearing to replace roller bearing for longer life and lower cost.

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Circle 539 on Page 19

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SELF LOCKING BOLTS and SCREWS

- Eliminate safety wire and lock washers
- Vibration and shock resistant
- Wide temperature range
- Save space and weight
- Speed assembly, cut costs

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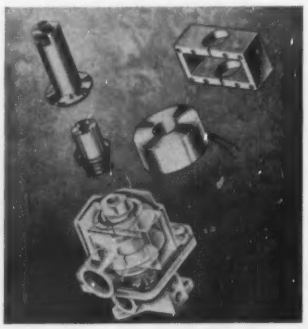
Circle 540 on Page 19



to resist corrosion. Soft synthetic inserts provide bubbletight sealing. **Skinner Electric Valve Div., Skinner Chuck Co.**, Dept. DCA-156, 105 Edgewood Ave., New Britain, Conn.

Circle 737 on Page 19

Glass Capillary Tubing

in sizes from 0.0015 to 0.014-in. OD

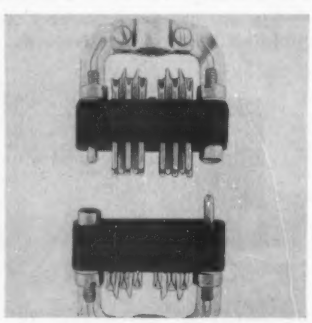
Micro-glass capillary tubing is available for use in research in the pharmaceutical, chemical, and electronic industries. Sizes range from 0.0015 to 0.014-in. OD, with standard tolerances held to ± 0.0002 in. Tubing is available in standard flint, noncorrosive flint, lead, and heat-resistant-type glasses. It is made in standard lengths of 6 ft or can be supplied to specifications. **Friedrich & Dimmock Inc.**, Millville, N. J.

Circle 738 on Page 19

Miniature Plugs

in 10, 16, 28, 34 and 50-contact layouts

Cannon/Tuchel microminiature and miniature plugs are designed for extensive use in aircraft, portable instrumentation, and other miniature electronic equipment. Plugs are available in 10, 16, 28, 34, and 50-



LOOK BEFORE YOU LEAP..

and you will SPECIFY THOMAS FLEXIBLE COUPLINGS

It is just plain common sense to "Look before you leap" when selecting a flexible coupling.

An inferior coupling causes wear and damage to your machines — resulting in high maintenance costs and costly shut-downs.

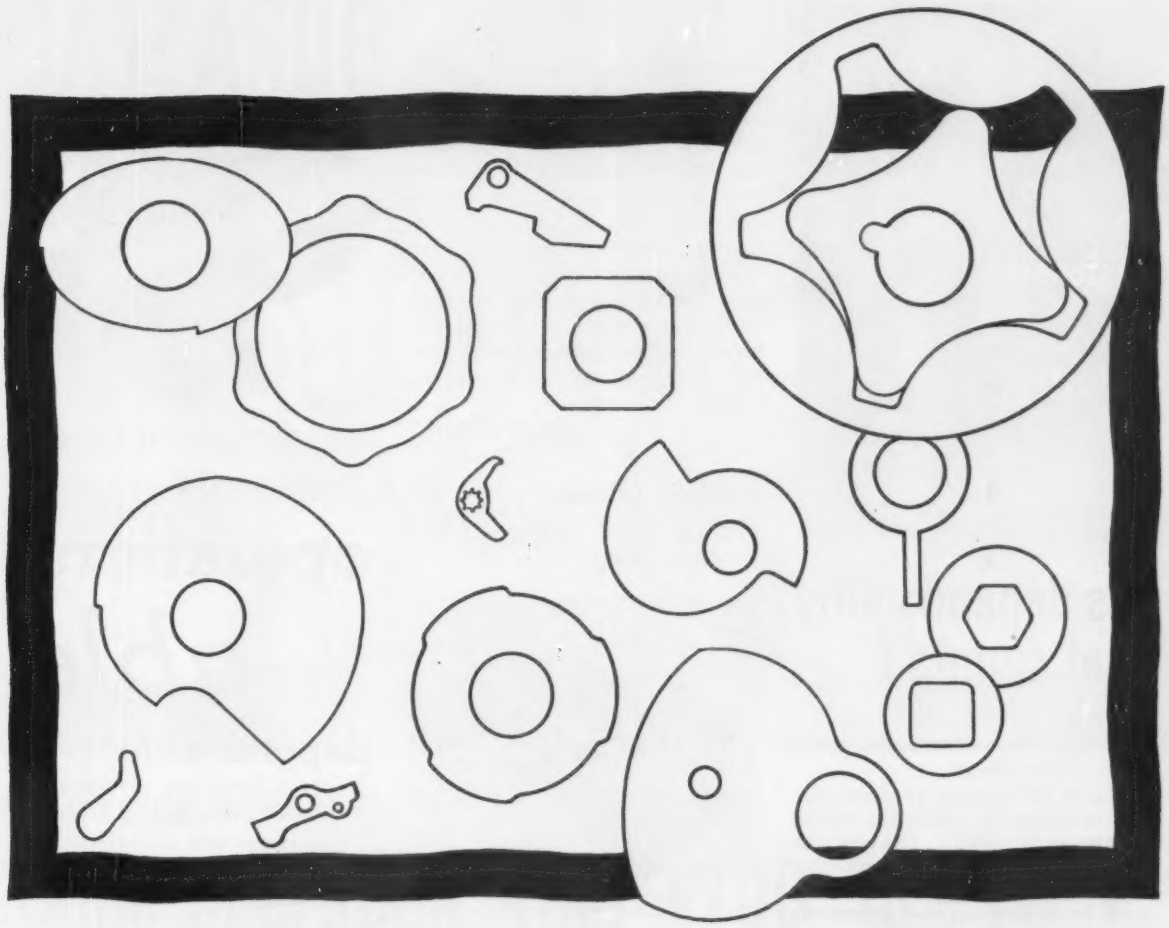
Troublesome maintenance problems are eliminated when you specify Thomas "All-Metal" Flexible Couplings to protect your equipment and extend the life of your machines.

NO MAINTENANCE
NO LUBRICATION
NO WEARING PARTS
NO BACKLASH

Write for Our New Engineering Catalog 60

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

Circle 541 on Page 19



NOT ALL GEAR SHAPERS CUT GEARS

. . . a lot of them are in production, cutting parts having non-involute shapes of various kinds. Many designers take full advantage of the versatility of the Gear Shaper by designing odd-shaped parts that can be easily and economically generated by merely using special Fellows cutters and fixtures on their standard Fellows machines.

The almost unlimited variety of work includes square and elliptical shapes, cams, pawls, pump rotors, etc., both internal and external.

Remember this *plus* value which helps guarantee a full, profitable work load on your Fellows generating equipment.

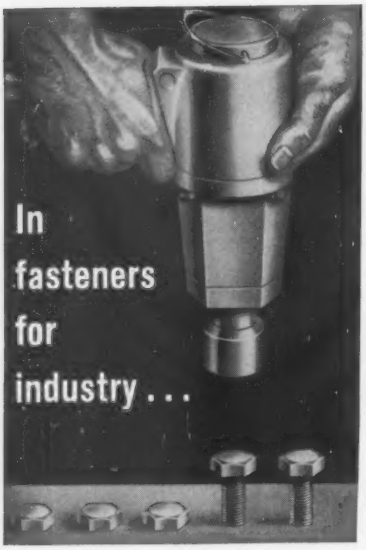
"The Art of Generating with a Reciprocating Tool", a fact-packed 48-page catalog, gives details on this versatile production technique. May we send you a free copy?

No. 4GS Fellows Gear Shaper

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont, U.S.A.
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N.J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE

Fellows *Gear Production Equipment*



it's dependability that counts !

Yes, *life* often rests on the dependability of the fastener.

Whether for bridges, pressure piping, skyscrapers, railroads, transformers or tunnels . . . or even your personal car, it's the *dependability of the fastener* that counts. The fastener must be *stronger . . . more dependable* than the part.

When you visit our manufacturing facilities and control laboratories, you will see for yourself how we build dependability into our IMPACT-FORM'D nuts, bolts and screws.

IMPACT-FORM'D Screw and Bolt fasteners are produced to customer demand every day:

- free—or interference-fit rail bolts
- high strength heat treated bolts for heavy construction
- close tolerance components for machinery
- screws for electronic equipment and accessories

Whether you follow industry standards or have your own specifications, IMPACT-FORM'D Screw and Bolt fasteners have the *dependability* you need.

VMA 6007

SCREW AND BOLT CORPORATION OF AMERICA
P.O. Box 1708 Pittsburgh 30, Pa.

DIVISIONS: *Pittsburgh Gary · Southington Hardware American Equipment*

America's Most Complete Line of Industrial Fasteners

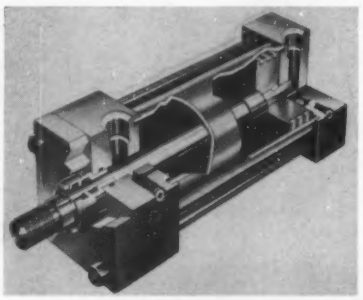
Circle 543 on Page 19

contact layouts. Insulation material is white polyester which withstands temperatures to 356 F. Nominal current per contact is 3 amp, and nominal voltage is 60 v. Contacts are silver-copper alloy and accommodate No. 26 gage wire. Female contact is constructed of "springy" parts which rub against male contact. In operation, male pin contact is gripped tightly by the female contact. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif.

Circle 739 on Page 19

Hydraulic Cylinders

for use with
1000-psi pumps



Power cylinders for use in medium-high-pressure hydraulic service, designated Series L, are designed for use with 1000-psi pumps. They are available in bore sizes from 1 through 8 in. Cylinders are of square head and tie-rod design, and provide case-hardened and hard chromium-plated piston rods as standard. Dripfree rods and leakproof ports are also furnished, and 14 different mountings are available. **Power Cylinder Div., Hannifin Co.**, Dept. 116, 501 S. Wolf Rd., Des Plaines, Ill.

Circle 740 on Page 19

DC Timing Motor

has Inconel rotor cage
to resist corrosion

Improved dc timing motor, Series MD-83, is a permanent-magnet type employing commutator and brushes of new and improved construction. Rotor cage of Inconel insures maximum life and corrosion resistance. Timing motor is reversible by changing polarity. Speed is directly proportional to

DURA SEAL

THE ENGINEERED MECHANICAL SEAL *presents*

operation -*able*

depend-*able*

Dura Seals are custom engineered and assembled to provide customers with mechanical seals that will meet their specific applications.

interchange-*able*

many component parts of Dura Seals are interchangeable — a feature that extends greater versatility and reduces inventories.

avail-*able*

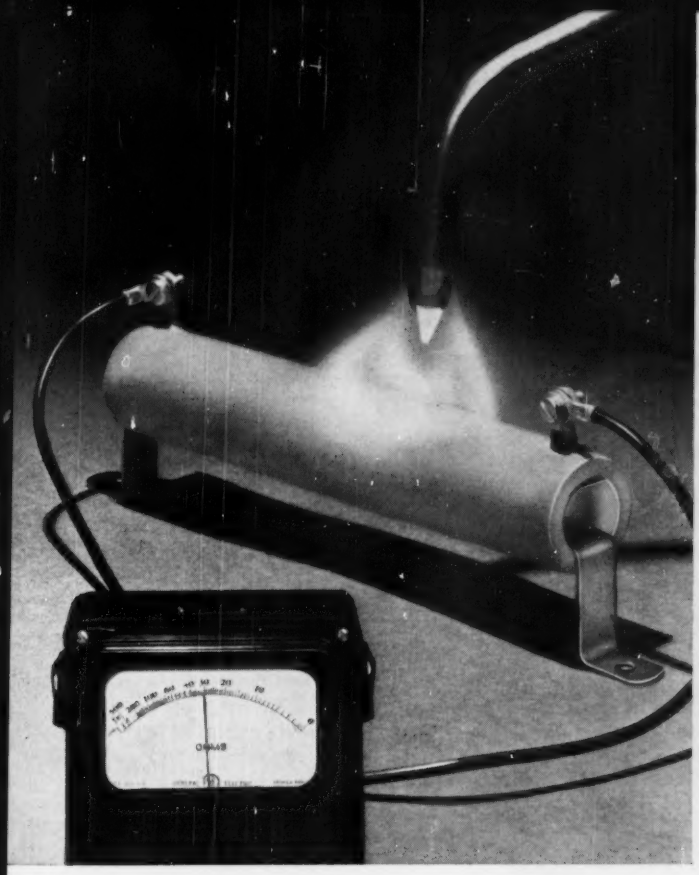
service interruption is minimized by prompt availability or replacement parts. Stocks are maintained at Baton Rouge, La., Borger and Houston, Texas, Kalamazoo, Los Angeles, Newark and St. Thomas, Ont., Canada.

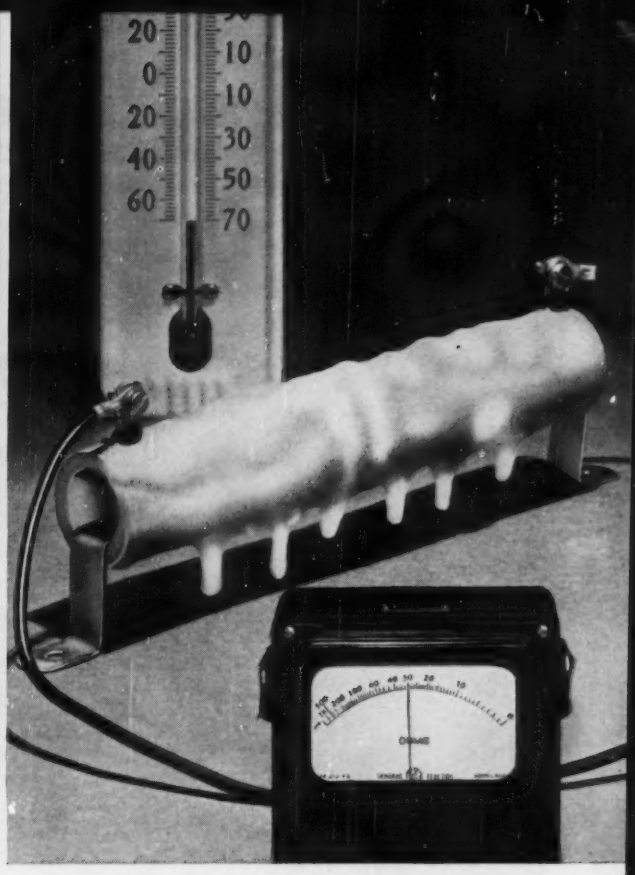
FOR FURTHER INFORMATION . . . WRITE FOR DURA SEAL CATALOG NO. 480MD

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN

Circle 544 on Page 19





TESTS ON NEW GENERAL ELECTRIC RESISTORS PROVE . . .

Stable operation from +700° to −70° F

Under searing heat or sub-zero cold, General Electric resistors maintain their rated ohmic values. Actual laboratory tests have proved that these vitreous-enameled resistors hold their rated resistance under ambient temperatures from +700 F to −70 F.

These General Electric resistors are available in over 1400 combinations of ratings (5 to 200 watts), types, and mountings. Stable operation is but one of their outstanding qualities: They have sufficient terminal strength to hold up to 21 pounds of right-angle pull, and special terminals are available to hold up to 34 pounds. Their vitreous-enamel coating provides resistance to adverse atmospheric conditions.

Like to know more? Ask your General Electric Apparatus Sales Engineer for a free set of sample resistors and test them yourself! And mail this coupon today for the 36-page catalog containing complete information on ratings, dimensions and ordering directions.

NEED OTHER COMPONENTS?

General Electric also has complete lines of contactors, relays, and plate rheostats for all your control needs. For more information, contact your General Electric Sales Engineer or mail this coupon today! Industry Control Department, Salem, Virginia.

GENERAL ELECTRIC

Circle 545 on Page 19

D-c contactors and relays—feature new "building-block" construction to give maximum flexibility with minimum inventory.

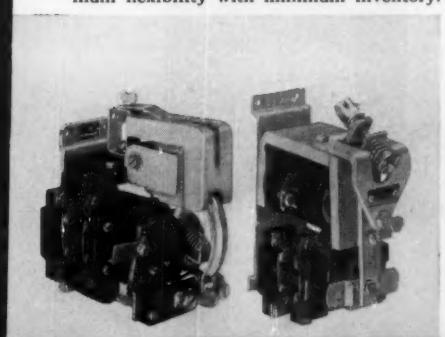


Plate-type rheostats—windings are completely encased in metal to give longer and more reliable service for any application.

To: Section 784-C23
General Electric Co.
Schenectady 5, N. Y.

Please send the following bulletins:

- ☐ GEA-6592—Vitreous-enameled resistors
- ☐ GEA-6474—Plate-type field rheostats
- ☐ GEA-6621—D-c contactors and relays

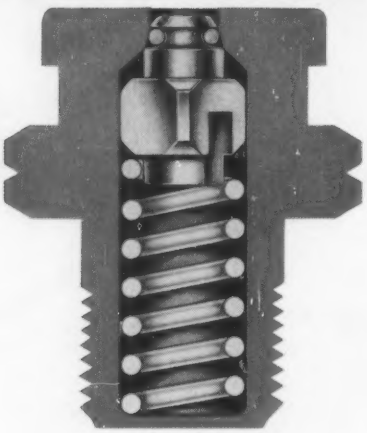
Name _____

Company _____

Address _____

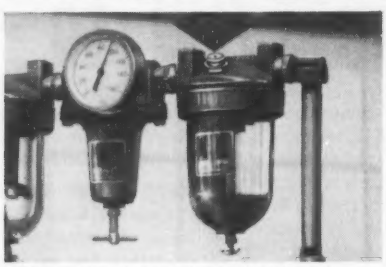
City _____ State _____

new from Lincoln

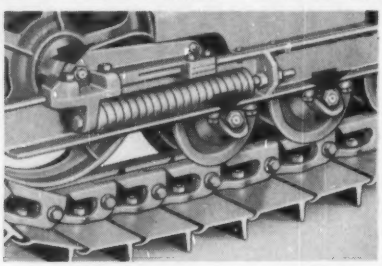


Model 5745

LEAKPROOF BUTTON HEAD FITTINGS



FOR FILLING AIR SUPPLY LINE LUBRICATORS WHILE AIR PRESSURE IS ON



FOR LUBRICATING TRACK ROLLERS ON CRAWLER TRACTORS

For *any* application where you want the oil or grease to get in the bearings *and stay there*, design *your* product with Lincoln's new Model 5745 leakproof (⅛" pipe thread) button head fittings.

Engineered to provide volume flow of lubricant without restriction, these fittings are precision-machined and case-hardened to withstand the extreme wear encountered on farm implements, contractors' equipment, conveyors and other types of heavy machinery.

Lincoln fittings provide a smooth surface for contact with the coupler, prevent excessive wear on coupler packing, and *will not "leak back"[1] or "drool".*

Lincoln

Specify Lincoln leakproof button head or hydraulic fittings as original equipment. Write the O.E.M. Division today for further information.

LINCOLN ENGINEERING CO.

Division of The McNeil Machine & Engineering Co.

4010 Goodfellow Blvd. • St. Louis 20, Mo.

6009

Circle 546 on Page 19

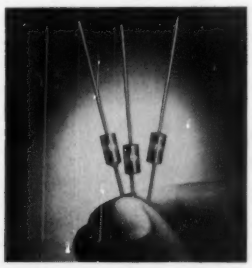
voltage, within specified limitations. Constant voltage speeds from 1/15 to 60 rpm, with standard windings, can be supplied. Standard voltages are 6, 12, and 28 v. Lifetime lubricated for maximum dependability, motor features a totally enclosed gear train. Mounting is interchangeable with all other Haydon timing motors. **Haydon Div., General Time Corp.**, 245 E. Elm St., Torrington, Conn.

Circle 741 on Page 19

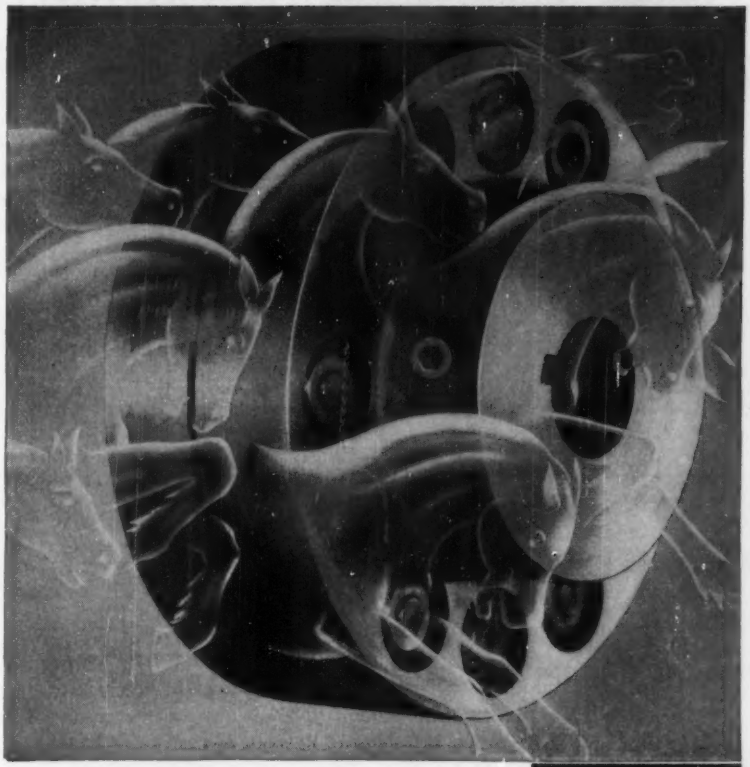
Silicon Diodes

miniature units provide ¾ amp dc output

New diffusion techniques have resulted in the first of a series of miniaturized 750 ma diffused-junction silicon diodes featuring low reverse current at rated peak reverse voltages, high surge-current rating, and low forward voltage drop at rated current. Axial-lead diodes are designed primarily for industrial and television applications where miniaturization and high power-handling capabilities are required. Complete series provides peak reverse voltage ratings of 200, 400, 500, and 600 v, and an operating temperature range from −65 to +130 C. Each junction is encapsulated in a stable, high-temperature, nonmetallic case, resulting in an excellent environmental seal.



ALL THE HORSEPOWER GOES THROUGH THE COUPLING

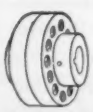


The Basic Reason Why it Pays to Use AJAX FLEXIBLE COUPLINGS!

For Original Equipment and Replacement... It costs far less to safeguard bearings, gears, impellers, armatures, housings, and other working parts than today's high cost of repairs and shutdowns!

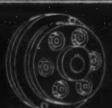
Whether you design, build, install, operate or service direct-connected machines, look into all extra economies of AJAX FLEXIBLE COUPLINGS.

Made in a complete line of types and sizes,—phone or write for catalog.



RUBBER-CUSHIONED SLEEVE BEARING TYPE

DIHEDRAL GEAR TYPE



Ajax Type SP Shear Pin Coupling

Ajax Type BO Bolt-On Coupling

Ajax Type M Mill Motor Coupling

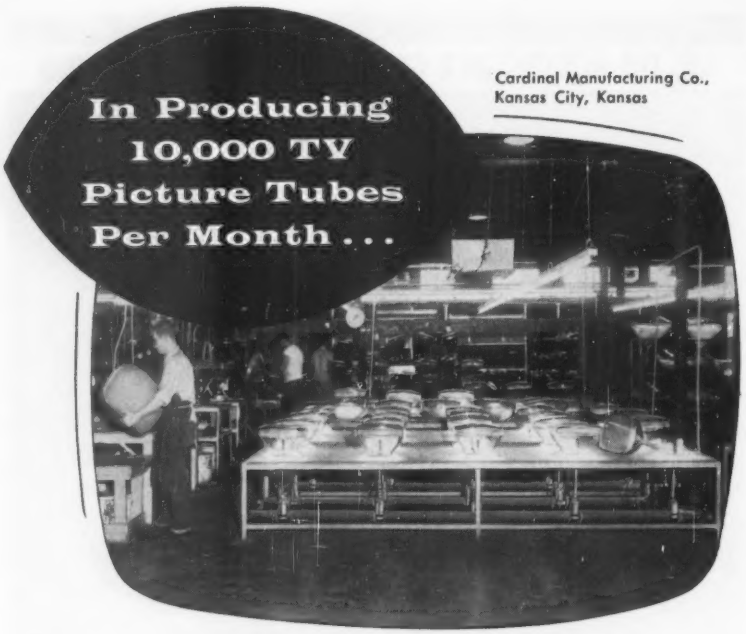
Ajax Type BD Brake Drum Coupling

AJAX

AJAX FLEXIBLE COUPLING CO. INC.
102 Portage Road, Westfield, N. Y.
In Canada—The Alexander Fleck, Ltd., Ottawa
Send catalog covering Flexible Couplings.

Name_____
Concern_____
Address_____

Circle 547 on Page 19



Cardinal Manufacturing Co., Kansas City, Kansas

An Unusual Problem . . .

How to dry picture tubes quickly—*from the inside*—after pouring screen. Natural drying had proved too slow—not only from an output standpoint, but also because the screening material lost its strength unless dried quickly. Narrowness of the necks of tubes posed a further problem . . . eliminated the use of conventional drying methods.

A Practical Solution . . .

A Spencer blower was arranged to deliver air at the required 165°F, utilizing controlled heat of compression. This heated air is carried through insulated lines to individual jets (each with multiple outlets) at rack-table arrangements. 110 tubes are processed simultaneously. Drying time of only 8 to 12 minutes is required.

BLOWER SPECIFICATIONS
TYPE: Spencer Turbo-Compressor
H.P.: 15
AIR DELIVERY: 450 C.F.M. @ 4 p.s.i.

Drop a line for information on how a Spencer blower—standard or specially adapted—might help solve your product or process design problem. Spencer blowers are available in standard capacities for 1/3 to 1,000 H.P., volumes up to 20,000 C.F.M. pressures 4 oz. to 10 lbs.

Request Catalog 126A containing complete specifications on Spencer Blowers.

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

Typical units measure 0.29 x 0.20 in. diam, excluding leads. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 742 on Page 19

Neon Lamps

for use as bright indicators or circuit components

Four new high-current lamps have voltage ranges from 55 to 80 v dc, and life to 5000 hr. Three units contain radioactive additive for reduced dark starting effect. Lamps are designed to be used as circuit components and bright indicators. Current is 6.0 to 20.0 ma. **Signalite Inc.**, Neptune, N. J.

Circle 743 on Page 19

Variable-Speed Sheaves

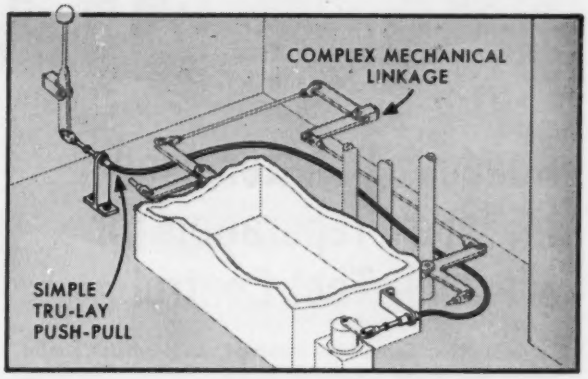
in two new sizes of 10 and 15 hp

Two sizes of MS variable-speed sheaves bring the number of models in this series to seven, covering a range of 2 to 15 hp. Additions are MS-100-10, 10 hp at 1750 rpm, and MS-100-15, 15 hp at 1750 rpm. Both have maximum pitch diameters of 10 in. Pulley design eliminates fretting corrosion as well as freezing and sticking. Torsionally resilient rubber keys located outside bearing surfaces transmit belt

Circle 548 on Page 19

TRU-LAY *PUSH-PULL* CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.

PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

6800-A East Acco Street, Los Angeles 22 • 929-A Connecticut Ave., Bridgeport 2, Conn.

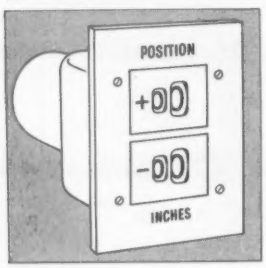
ACCO

Circle 549 on Page 19

Veeder-Root READOUT Bulletin

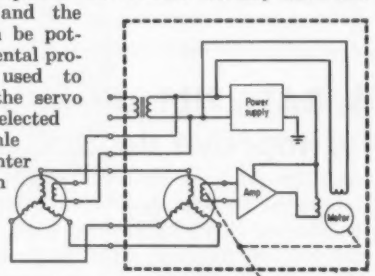
Readout Counter used in Tape Preparation for Machine Tool Control

A Veeder-Root Series 1538 Remote Data Readout Counter provides tape feed control for the motorized tape punching unit of the new Potter & Johnston Tape Control System. The tape punch is used to program machine functions on P & J Automatic Turret Lathes. The counter automatically controls the amount of tape feed required for each turret face involved, and stops the tape at preselected address points. When the correct address point is reached, a combination of holes representing the machine command is punched into the tape. Counter is automatically reset for each turret face.



Servo Repeaters Drive Counters to Indicate Lineal Motion*

One of the ways to take advantage of digital readout for indicating and recording information at remote points is through servo repeaters. Applications in aircraft, for altimeters, navigational displays and similar instrumentation, suggest many other opportunities to use counters for more positive indication and control. A typical "system" is shown here where a counter is used for indicating nuclear reactor rod position. The servo repeater and counter actually form one packaged unit, and the whole device can be potted for environmental protection. When used to drive counters, the servo gear ratio is best selected to provide full scale travel of the counter for one revolution of the control transformer shaft.

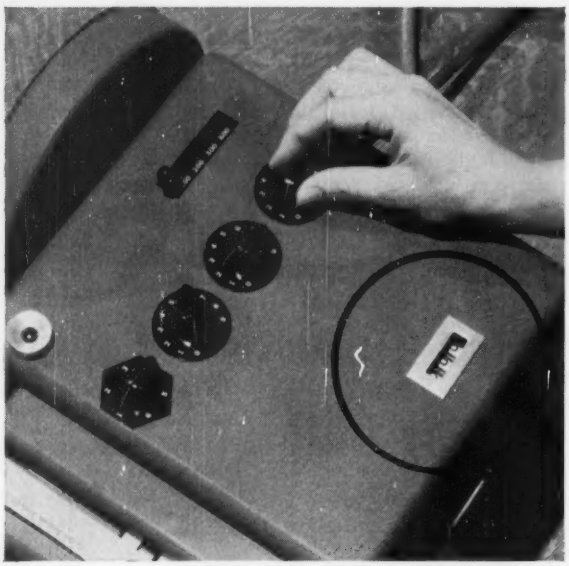


Typical servo repeater/counter device that converts synchro data to digital readout.

Output shaft to counter

Let Veeder-Root help you make Counters do more! Extensive design experience and precision production techniques make it possible for Veeder-Root to help you solve a wide variety of digital, readout, control and recording problems with counters — from the simplest ratchet to advanced readout and navigational devices. Send for information on specific applications or contact your local Veeder-Root Counting Engineer.

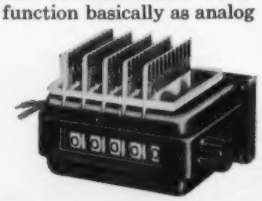
*Reprinted from CONTROL ENGINEERING June 1959. Copyright© 1959 by McGraw-Hill Pub. Co., Inc. All rights reserved.

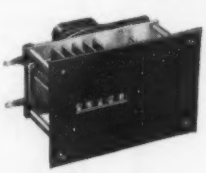


Veeder-Root Readout Device

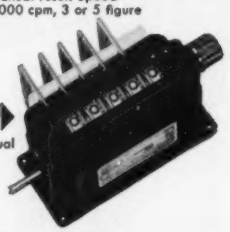
This is the basic series of Remote Data Readout Counters. Some are available for standard applications, or design variations will be submitted based on requirements. They function basically as analog to digital converters.

Series 1538/electrical reset/ electrically actuated. Speed 1000 cpm, 3 or 5 figure





Series 1538/electrically actuated/ manual reset. Speed 1000 cpm, 3 or 5 figure



Series 1606/mechanically actuated manual reset standard; bi-directional (non-reset) available. Speed 5000 cpm, up to 5 figures

Veeder-Root

HARTFORD 2, CONNECTICUT

"The Name that Counts"

New York • Chicago • Los Angeles • San Francisco • Seattle
St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal
Offices and Agents in other principal cities

torque. Bearing surfaces are reoiled with each rotation of the pulley. Sheaves are designed for use with angled motor bases and V-groove companion sheaves to provide a V-to-V drive. **T. B. Wood's Sons Co.**, Chambersburg, Pa.

Circle 744 on Page 19

Spring Wire

for 600 to 1000 F service

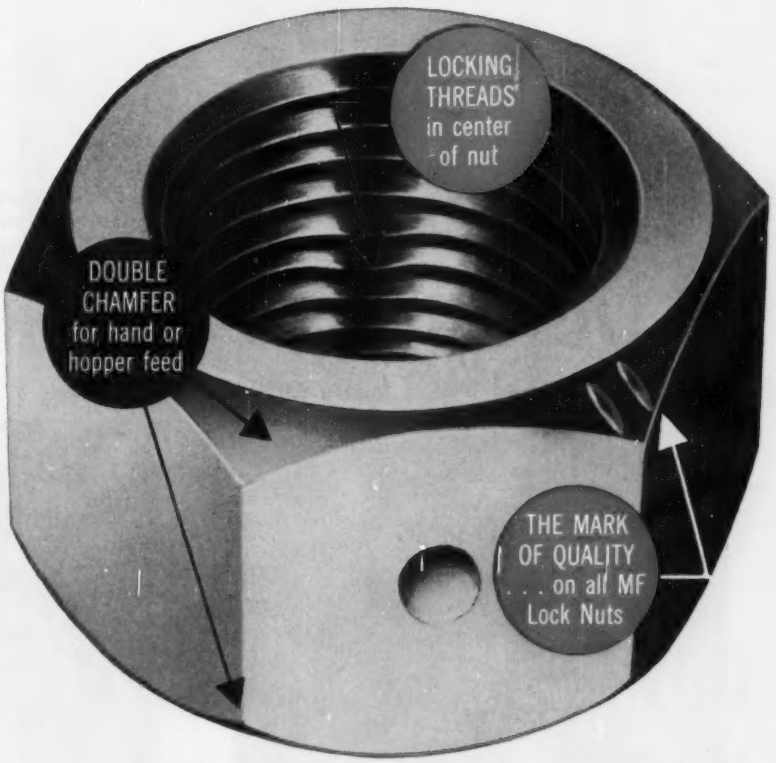
Precipitation-hardening austenitic alloy, NS-A286, is available for spring wire for 600 to 1000 F service. Low-cost material is finding initial application in jet engines and gas turbines. It experiences as little as half the percent-relaxation loss at 1000 F as comparable alloys at 850 F. Sixteen hours at 1350 F precipitation-hardening is recommended for springs after they are coiled to increase physical properties and to improve stability to 600 to 1000 F. **National-Standard Co.**, Niles, Mich.

Circle 745 on Page 19

Reversible Timing Motors

feature brake and clutch action

Reversible timing motors incorporate automatic braking and clutching actions made possible by causing motor to shift axially when motor coils are energized. De-energizing the coils results in a positive brake action which renders motor particularly suitable for remote adjustments of potentiometers, condensers, and other control devices. Shift action can be modified to provide a free shaft when motor is de-energized. Modification is primarily recommended for timing or for other applications where motor is required to have a positive drive when energized and no drag on output shaft when de-energized. Automatic brak-



Build better products...faster...with

MF TWO-WAY LOCK NUTS!

The MacLean-Fogg Two-Way Lock Nut has the features designers and production men want. Check them off: (1) It is double chamfered—goes on from either side—is ideal for either hand or hopper feeds. (2) The lock is in the center of the nut—permits fastest starts—allows bolt end to be below or flush with top of nut. (3) Two-Ways are economical; reusable; better looking on your finished product.

Circle number on reply card for catalog and technical data.

MF MAC LEAN-FOGG LOCK NUTS

MacLean-Fogg Lock Nut Company
5535 N. WOLCOTT AVENUE
CHICAGO 40, ILLINOIS

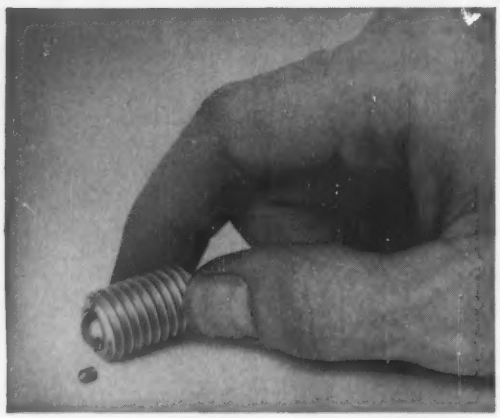
1925 35 1960 ANNIVERSARY

Circle 551 on Page 19

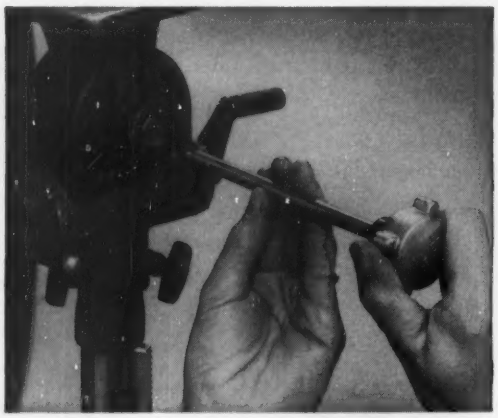
Practical Design Tips

No. 4 of a series

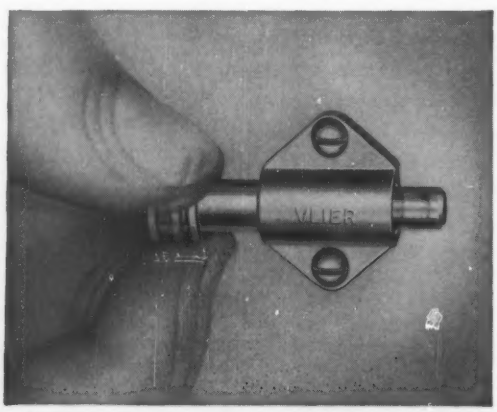
Hundreds of companies are now saving by using off-the-shelf Vlier products like the ones shown below. These simple, low cost, precision parts save designers time and, in many cases, simplify product design and manufacture. Why not investigate their possibilities today.



BALL PLUNGERS WORK BETTER than spring plungers when side loads are involved. Balls won't bind from side thrusts, retract easily. Available in new, "Mini-ball" sizes, down to #4-48x3/16"; standard sizes from #10-32x1/2" to 5/8-11x1". Various end pressures.



TORQUE-LIMITING WRENCH for assembling small parts, adjusting set screws, etc., is easily made from a Vlier Torque Handle and a length of hexagon stock. Prevents over-tightening, and subsequent damage to parts. End pressure is adjustable from 15 to 200 lbs.

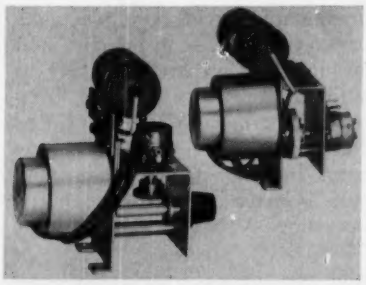


NEED A SMALL, LIGHTWEIGHT, SPRING-LOADED LATCH? One enterprising designer modified a standard Vlier S-88 Spring Stop that did the job perfectly. Entire latch weighs less than 1/3 oz. Body is die-cast aluminum; plunger is heat-treated alloy steel. Various plunger pressures. Available on quantity orders only.

FREE IDEA BOOKLET. Illustrations in this 16-page booklet show how others have profited from the use of Vlier products. Illustrates both the usual and unusual applications. May suggest ways *you* can save. Write for your copy today.

VLIER
Engineering Corporation
A subsidiary of Barry Controls, Inc.
8900 Santa Monica Blvd. • Los Angeles 46, California

Circle 552 on Page 19



ing and clutching features are available on complete reversible-motor line. **Bristol Motors, Div., Vocaline Co. of America,** Old Saybrook, Conn.

Circle 746 on Page 19

Pressure-Sensitive Tape

of Teflon for high-temperature design

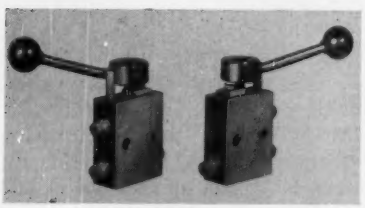
Temp-R-Tape TSP noncorrosive, pressure-sensitive tape utilizes a silicone-polymer adhesive and a skived Teflon-film backing to which a special primed surface is applied. Total thickness of the tape, available for high temperature design, is 0.006 in. Treated surface accepts encapsulating resins and electrical varnishes, and can be marked with almost any commercially available ink. Tape is recommended for electrical applications where high dielectric strength, low power factor, and negligible moisture absorption are important. High elongation provides a tight wrap over sharp bends and compound surfaces. Tape is immediately available from stock in ½ to 1-in. widths, in 18-yd rolls. **Connecticut Hard Rubber Co.,** 407 East St., New Haven, Conn.

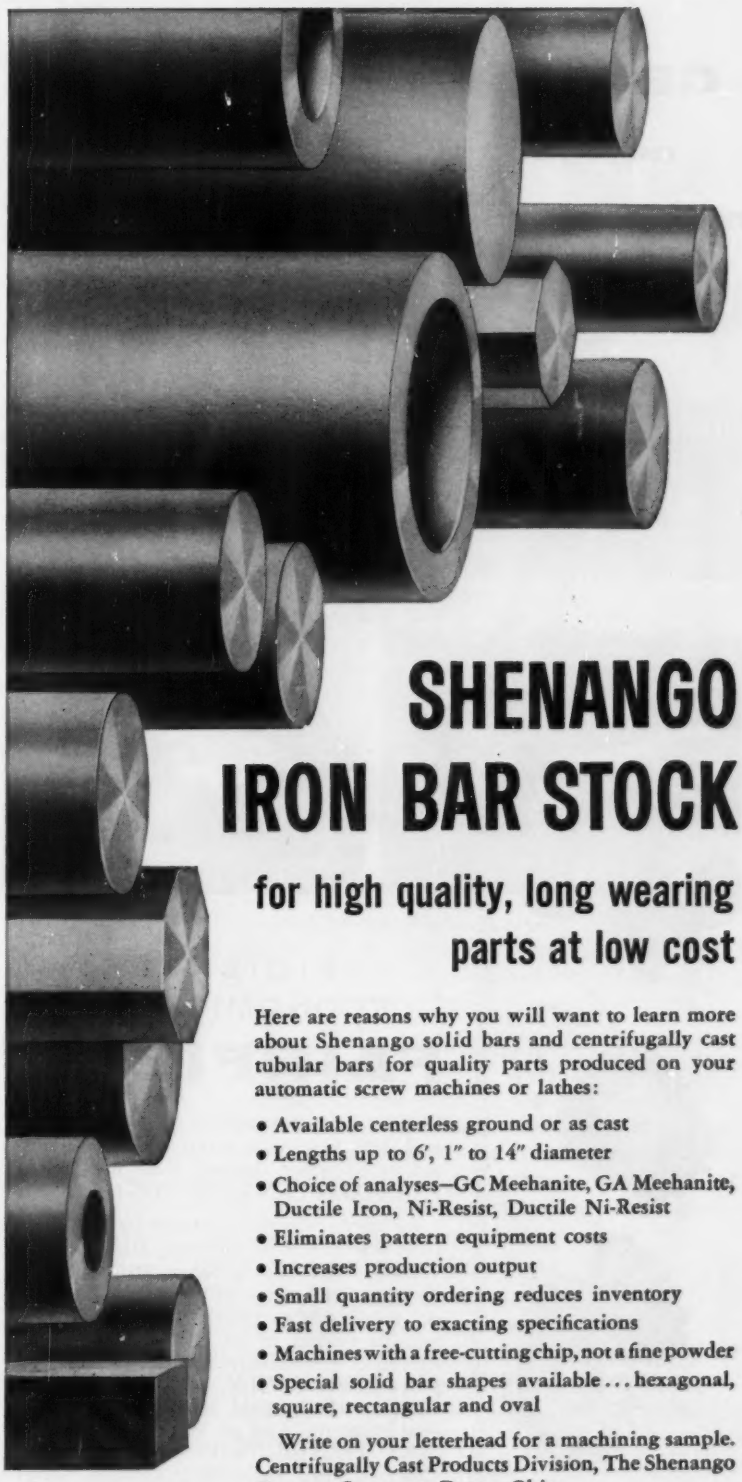
Circle 747 on Page 19

Three-Way Valve

for hydraulic circuits with pressures to 10,000 psi

Three-way, on-and-off valve is available for remote control of hy-





SHENANGO IRON BAR STOCK

for high quality, long wearing parts at low cost

Here are reasons why you will want to learn more about Shenango solid bars and centrifugally cast tubular bars for quality parts produced on your automatic screw machines or lathes:

- Available centerless ground or as cast
- Lengths up to 6', 1" to 14" diameter
- Choice of analyses—GC Meehanite, GA Meehanite, Ductile Iron, Ni-Resist, Ductile Ni-Resist
- Eliminates pattern equipment costs
- Increases production output
- Small quantity ordering reduces inventory
- Fast delivery to exacting specifications
- Machines with a free-cutting chip, not a fine powder
- Special solid bar shapes available . . . hexagonal, square, rectangular and oval

Write on your letterhead for a machining sample. Centrifugally Cast Products Division, The Shenango Furnace Company, Dover, Ohio.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • MANGANESE AND ALUMINUM BRONZES
MONEL METAL • NI-RESIST • MEEHANITE® METAL • ALLOY IRONS • DUCTILE IRON

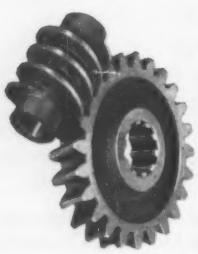
Circle 553 on Page 19

GEARS to drive newest machines...

produced by

EFFICIENTLY, ECONOMICALLY

FAIRFIELD



Getting into production on new models and new machines often calls for quick action to meet desired time schedules. FAIRFIELD CAN HELP YOU!

As one of America's largest independent producers of GEARS and DIFFERENTIALS, Fairfield's facilities are complete. You get the benefits of newest high capacity machines coupled with regular big volume output in an ultra-modern plant designed exclusively for producing fine gears EFFICIENTLY, ECONOMICALLY. Check with Fairfield NOW on your gear requirements. *Call or write.* FAIRFIELD MANUFACTURING CO., INC., 2307 S. Concord Rd., Lafayette, Indiana. Telephone 2-7353.

Gears and Differentials For FINE GEARS *Made to Order for:*

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

draulic units having spring, manual, or gravity-ram return. No. 1734A is intended for hydraulic circuits with pressures to 10,000 psi. Control handle moves to three positions —ram advance, hold, and ram return. In hold position, ram pressure is maintained while pump is operating. Valve block has three $\frac{3}{8}$-in. NPT pipe outlets, one for high-pressure take-off, and two for high- and low-pressure take-off from the pump. **Greenlee Tool Co.**, Rockford, Ill.

Circle 748 on Page 19

Electric Counter

for high, medium, or low speed use

Model 6-Y-1-RMF electric counter has a life rating of 30 million counts at a speed of 1000 counts per minute, with operating speeds up to 1200 cpm at normal voltage. Counter is accurate at high, medium, or low speeds. It features a strong, silent, fast-operating solenoid, with a compact, built-in rectifier for ac operation. Precision-molded plastic number wheels are sharply printed with large white figures on a black background. Counter, corrosion-resistant throughout, is housed in a rigid, one-piece, die-cast frame. It is not affected by shock and vibration. **Durant Mfg. Co.**, 1933 N. Buffum St., Milwaukee 1, Wis.

Circle 749 on Page 19

Spray Nozzle

has square spray pattern

New spray nozzle provides a full square-spray pattern and wide-angle projection. It is available for installation on spray manifolds where open area is dimensionally limited. Average spray angle of 110

Circle 554 on Page 19

How KEYSTONE *Quality Control*

stands-in for you throughout our operations

People of unquestioned authority in our plant are the quiet men in control of quality. You meet them everywhere, in lab jackets or work shirts, along the flow of a thousand different production items from raw materials to shipping pallets. It's the job of Keystone Quality Control to make sure that material specs are met, that dimensional accuracy is on the nose—these things, and many more.

If your part is heat treated for desired final physicals (we carburize, carbonitride and anneal by the most modern methods available), our quality people see that the properties are there. They also check to assure precise density control and completely alloyed structures, so that tensile and crushing strengths and other values will measure up at all stages of the process.

Equipment, as well as people, are key factors in close control of quality. We pride ourselves in having the most complete inspection department so that all our checking can be directly compared with yours. From the simplest mechanical gauges, through visual comparators (up to 30-inch), to the ultra-accurate electronic measuring apparatus for super-close checking, we are with you all the way.

What can this mean to you? Just this. For many of America's leading manufacturers Keystone is a "Certified" vendor whose shipments receive only periodic spot checks. That's confidence, and *time and money savings, too.* We'd like to tell you the rest . . . and show you. If you're a user of metal powder parts or expect to be soon—come and see for yourself. *Why not set a date?*

Keystone CARBON COMPANY
POWDERED METAL PARTS DIVISION
ST. MARYS, PA.

Circle 555 on Page 19

ROLLWAY MAXIMUM BEARINGS

. . . . . What's the limit: Heat? Shock? Speed? Or complicated radial and thrust loads?

Name the combination of requirements . . . and chances are you'll find them met by a Rollway Maximum precision radial cylindrical roller bearing. If not, then Rollway engineers will modify any factor to meet your application.

Rollers are crowned to prevent end-loading and the resultant spalling of races. Directional trueness is maintained by retainers of standard bronze or "Rollube" ferrous alloy of one piece or two piece construction.

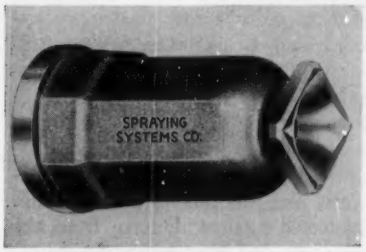
You may wish to refer to the Rollway Catalog and Engineering Data Book when writing specifications for a high precision bearing. It contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings. Send for it today.

ENGINEERING OFFICES:

Syracuse Boston Chicago Detroit
Toronto Pittsburgh Cleveland
Seattle Houston Philadelphia
Los Angeles San Francisco

ROLLWAY®
BEARINGS
COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

Circle 556 on Page 19



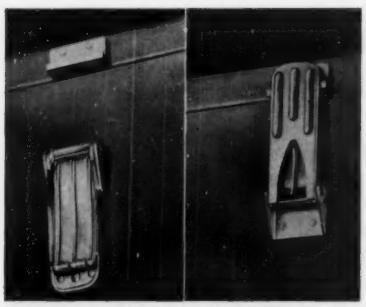
deg provides wide coverage within a short distance between spray nozzle and work. Square spray pattern on manifold, multiple-nozzle installations permits keeping spray overlap to a minimum while still providing total coverage. Nozzles are supplied in capacities from 5.9 to 48 gpm at 30 psi, in male or female pipe connections. **Spraying Systems Co.**, 3274 Randolph St., Bellwood, Ill.

Circle 750 on Page 19

Container Latch

has ultimate tension limit of 1000 lb

No. 46L container latch with only five parts has an ultimate tension limit of 1000 lb. Over-center toggle geometry is built within the latch itself, eliminating any possibility of the latch springing open due to movement of container sections



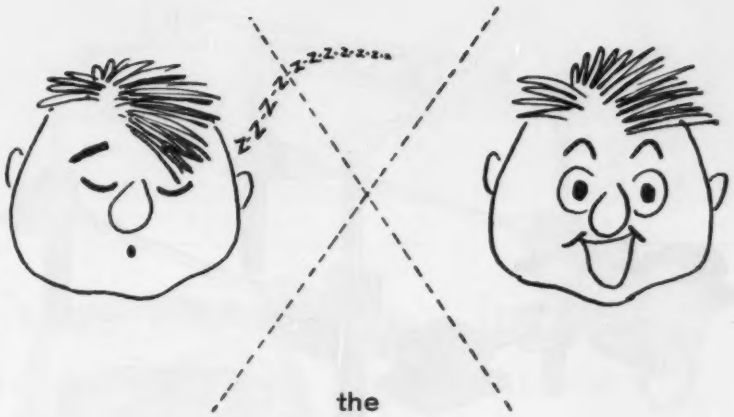
caused by shock, vibration, buckling, or misalignment. **Camloc Fastener Corp.**, 22 Spring Valley Rd., Paramus, N. J.

Circle 751 on Page 19

Weatherproof Motors

have epoxy-encapsulated insulation system

Duty Master weatherproof ac motors are available in frames 180 through 445U (1 through 125 horsepower) in all standard speeds



the importance of being

BISTABLE

(especially if you're a transistor driving a relay)

If you've been toying with the idea of using a transistor circuit to drive a relay, here are some facts of life that may save you grief later on. The watchword is bistable operation — particularly with regard to the transistor.

What can make a mess of an otherwise compact, cool, low standby-power transistor is a driving circuit that leaves the little pill neither saturated nor cut off. The transistor is then very apt to become an unstable, variable gain amplifier, when it should be taking a firm stand in favor of either "on" or "off". The thing to do is design the input circuit properly so that *it* is responsible for the transfer from one stable state to the other. (The Schmitt trigger circuit is an excellent for instance.)

Once you've got the transistor operating as a flip-flop and not as an amplifier, a good relay to use is a bistable type. Then the relay simply monitors the condition of the driving circuit, and success is practically around the corner (maybe). Magnetic latching relays are just such switches — and they have the added advantage of needing no standby power. Naturally, we have all sorts and kinds which all carry the designation "Form Zzzzz."

You won't be completely out of the woods, however, until you've given some thought to (a) operating speed and (b) nature of the transistor load. As for the former, you may be on the verge of transistorizing a tube-relay circuit and wonder why, all else being equal, the relay will operate slower from transistors. Although the transistor will do all sorts of wonderful things on less power, one thing it won't do on less power is hurry the relay. The remedy is adding some external resistance and raising the source voltage — or lowering the impedance of the relay. As for the load the transistor must switch, it is well to remember that if it's inductive (and a relay coil is) and the energy cannot be safely dissipated in the transistor, you'd better find another outlet. The lack of "arc suppression" in transistor circuits, when needed, may not produce juicy blue sparks but the result is the same — quite rapidly.

Some of our application engineers are notoriously bistable, and depending on which state they are in when they hear from you, will undoubtedly send you either (+) circuit design ideas (based on the use of a Sigma relay) or (−) some zzzzz-inducing printed material on bistable applications. Zatisfaction guaranteed.

SIGMA

SIGMA INSTRUMENTS, INC.
89 Pearl Street, So. Braintree 85, Mass.
AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1938)

Circle 557 on Page 19

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for **AD-66av.**

DUFF-NORTON COMPANY

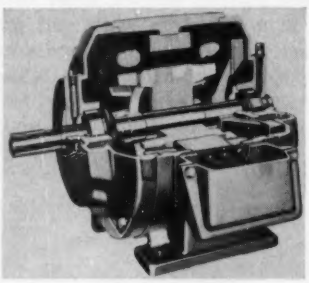
Four Gateway Center • Pittsburgh 22, Pa.

COFFING HOIST DIVISION • Pittsburgh, Pa.

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

and voltages. Motors have an epoxy-encapsulated insulation system. Stator windings are thoroughly encapsulated in epoxy resin for resistance to moisture, oils, dust, chemicals, acids, and alkalies. Bearings, exposed internal metal surfaces, hardware, and mechanical parts are also protected against damage from the elements and contaminating atmospheres. Class B insulation system employs polyester round-copper magnetic-coil wire, epoxy-insulated glass-fiber sleeving, epoxy-treated



glass-fiber cloth slot liners, and phase insulation. Separators and top sticks are glass-mat base epoxy-resin laminate, and lead cable is protected by moistureproof silicone rubber. Motors have solid cast-iron frame. **Reliance Electric & Engineering Co.,** 24701 Euclid Ave., Cleveland 17, Ohio.

Circle 752 on Page 19

High-Gloss Plastic

for molded and sheet consumer products

Easy-processing, high-gloss variety of Kralastic ABS plastic, called Kralastic MH, is now available for molded and sheet consumer products. Kralastic ABS plastics have good dimensional stability, high mechanical strength, and excellent resistance to impact, corrosion, cold flow, and heat. Composition of Kralastic MH has been modified so it can be molded at high speeds, and molded parts have gloss and decorative appearance. Processing techniques used with the material include injection molding, vacuum forming, and sheet or profile extrusion. Molded parts can be machined, drilled, painted, metallized, cemented, and nailed. Plastic withstands continuous exposure to temperatures to 185 F. It has good abrasion and mar resistance, and is

R B & W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of gasketed joints

The right fastener for a "flexible" joint rests on type of gasket material and its compressibility. Total preload on all the fasteners in the connection must be enough only to compress the gasket and provide sufficient additional clamping force to withstand the hydrostatic test pressure. More than this brings on a good chance of leakage, through "bowing" of the clamping plate.

Exaggerated sketch showing how too much torque tends to distort clamping plate and leads to leakage.

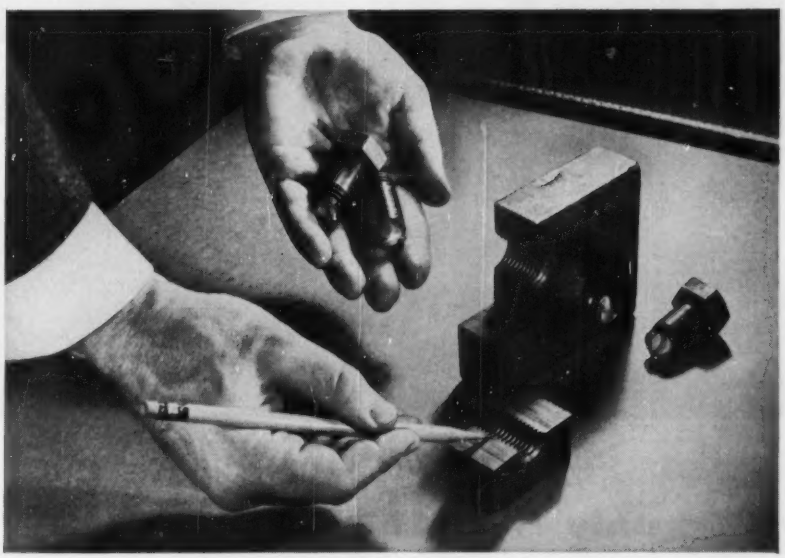
HYPOTHETICAL CASE

Suppose a joint is tightened with Grade 5 Hex Screws to their yield strength, and leakage develops. By going to alloy screws and tightening still further you would still get leakage. But Grade 2 Hex Screws, all torqued evenly, would no doubt solve it.

ACTUAL CASE

The fasteners on one product's flange had to withstand a 4000 pound hydrostatic pressure. But the hard asbestos gasket used took a bolt load of 28,000 pounds for sufficient compression to seal. By substituting a rubber and fibre gasket in this case, bolt load could be reduced. So could bolt size, thereby saving 73% on fasteners.

Using Hex Screws in tapped holes saves money



In the cast "coupon" shown above, the hex screws were torqued tight and removed 50 times—then torqued to failure. Note in the cutaway that the casting's threads are still perfect with no sign of stripping. It was the screws which broke—a clear demonstration that castings fastened with hex screws will suffer no thread damage during repeated disassemblies.

TWOFOLD BENEFIT

When there are no space clearance problems or other special requirements, using studs of 1-inch diameter or smaller often penalizes the user. First, in direct costs, since the more economical hex head screws will do the job to specification. And second, in production costs, since studs require that tapped holes have an *interference* thread fit, which in turn results in slow, "selective" assembly to determine properly mated threads. Hex screws need only a *clearance* fit, assemble faster.

ACTUAL EXAMPLE

In one of his surveys of fastenings used by one company, the RB&W engineer pointed out that over 250 stud fastenings were being used in a large refrigeration unit. The same number of hex screws, costing $8.45, saved $22 over the studs and nuts. Annually, the total would be $7,800 on the production run of this unit.

Not to be overlooked either was the tangible saving on the less critical tapping job required.

RB&W offers its help on your specific fastener problems, or an overall survey of your fastener usage. Contact Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle 559 on Page 19

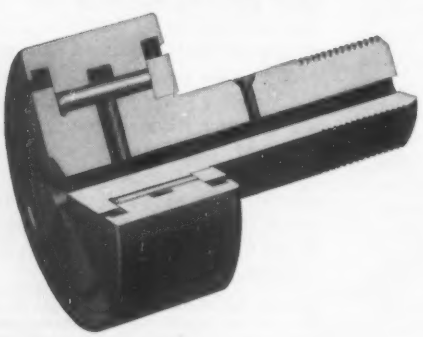
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4" are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

Write for Catalog No. 52-A

engineered electrical products

McGILL®

precision needle roller bearings

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

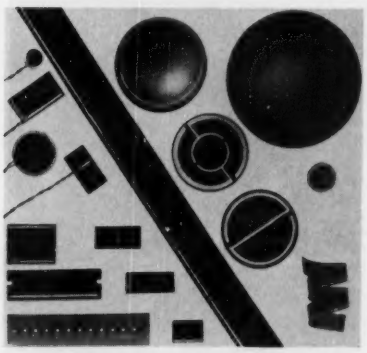
Circle 560 on Page 19

not corroded by a range of acids and oils. Naugatuck Chemical Div., United States Rubber Co., 1230 Avenue of the Americas, New York 20, N. Y.

Circle 753 on Page 19

Photoelectric Cells

are 50 per cent more sensitive than previous units



Type 5 photoelectric cells, available in almost any shape or size to meet exacting specifications, are 50 per cent more sensitive than previous cells. The self-generating selenium units are available in various spherical or cylindrical shapes, or as flexible strips which can be twisted into a variety of spiral designs. Sizes range as small as 1/16 in. square. Current sensitivity has been increased by 2 to 1 ft-c, and potential sensitivity has been increased by 5 to 1 ft-c over former cells. Incorporating barrier-layer design, cells have highest output consistent with stability, and are highly resistant to mechanical damage. They convert light energy into electrical energy without physical or chemical change in light-sensitive components. Weston Instruments Div., 614 Frelinghuysen Ave., Newark 12, N. J.

Circle 754 on Page 19

Transistor Clip

for vertical or horizontal mounting

Subminiature transistor clip formed of tempered beryllium copper and finished with a flat black matte is suitable for vertical or horizontal mounting. Clip has a case of 0.300 to 0.324-in. diam, and is available in two lengths to accommodate most

as much yours as though they came off your own board

CUSTOM ENGINEERED

power units by WISCONSIN

AVAILABLE MODIFICATIONS

FUEL SYSTEM — gasoline, natural gas or LPG (for domestic use) and alcohol, kerosene, or No. 1 fuel oil (for export).

ELECTRICAL EQUIPMENT — electric starter-generator system or electric starter only for all models. Solenoid switches and automatic choke, for remote or automatic starting, also available.

HYDRAULIC POWER — all Wisconsin V4's can be equipped with integrally-mounted hydraulic pump.

POWER DRIVE — centrifugal clutch; over-center clutch; clutch reduction or reduction assembly in a variety of ratios; adaptor to take a spring-loaded clutch; or transmission-torque convertor designs.

DIRECT DRIVE — special crankshaft extensions are available threaded, tapered, splined, special diameters and lengths, various keys, etc., for close-coupled pumps, generators, and other equipment.

SAFETY DEVICES — low-oil-pressure cut-off switch for 2- and 4-cyl. models, and high-temperature safety switch for all models.

OTHER ACCESSORIES — automotive and spark-arresting mufflers, pre-cleaners, drive pulleys for flywheel, and rewind starters for ACN and BKN engines.

Do you have a special power problem? If you do, you can save development time and cost by letting Wisconsin help you solve it — with *custom-engineered* modifications to meet your particular installation requirements down to the smallest detail.

Our "spec" engineers are power specialists, backed by over 50 years of engine specialization. They can draw on a wealth of problem-solving experience in every field of engine-power application. Their counseling is part of Wisconsin custom-engineering service — and it doesn't cost you a red cent.

For best results, consult our engine specialists during the preliminary and design stage of your product development. In the meantime, send for Bulletin S-249 and familiarize yourself with the entire Wisconsin line of air-cooled engines — 3 to 56 hp. Write Dept. O-10.

WISCONSIN MOTOR CORPORATION

MILWAUKEE 46, WISCONSIN

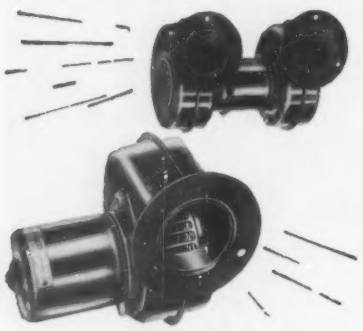
World's Largest Builders of Heavy-Duty Air-Cooled Engines

O-148

Circle 561 on Page 19

put HEINZE in your designs

BLOW AWAY HOT PROBLEMS



with HEINZE D BLOWERS

Heinze D Blowers dissipate heat in a variety of cooling operations — such as in electronic equipment, vending machines, refrigeration units, induction heaters, photographic dark rooms.

Single unit delivers up to 55 cfm at 3200 rpm; double unit operates at 3100 rpm to deliver 100 cfm.

Both units are powered by long-lasting, trouble-free 2 pole induction motors, with hp ratings from 1/150 to 1/100, CW or CCW, 115V, 60 cycle. Other voltages or 50 cycle operations are available.

Send coupon for catalog.

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685 Lawrence St.
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SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

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685 Lawrence St., Lowell, Mass.

Please send free catalog on Heinze Sub-Fractional Horsepower Blowers and Motors.

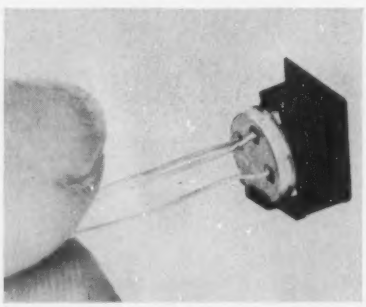
Name & Title.....

Company.....

Street & No.....

City & State.....

Circle 562 on Page 19



styles of medium-power TO-5 transistor cases. Small, turned-up tab at one end catches rim of transistor and forces top against a large, flat back-plate which serves as a heat sink and radiation member. Another small tab on the bottom is depressed into mounting surface, providing a firm grip and preventing clip from twisting. Entire clip is formed from one piece of material, and its total weight is 3/100-oz, yet it has excellent holding power and ability to dissipate heat. **Atlee Corp.**, 47 Prospect St., Woburn, Mass.

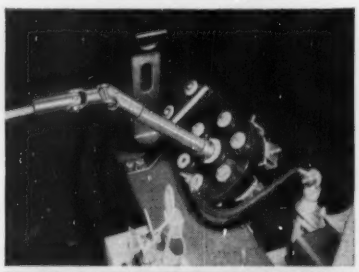
Circle 755 on Page 19

Ball Valves

for operating temperatures to 150 or 250 F

Top-entry, top-adjusting thermoplastic ball valves are made of unplasticized polyvinyl chloride for operating temperatures to 150 F and Penton chlorinated polyether for hot corrosive service to 250 F and higher. They are furnished in ½ through 3-in. nominal pipe sizes, threaded or socket type. Top-entry feature of the new ball valves makes it possible to perform on-the-line maintenance almost instantaneously. Easy access to working parts without disconnecting piping is achieved by unscrewing valve bonnet and lifting out molded, one-piece ball-and-stem and self-lubricating Teflon seating inserts. Adjusting nut on the valve bonnet enables adjustment of

CURTIS HELPS THIS SWITCH LIVE TO A RIPE OLD AGE



Pad-mounted transformers for underground power distribution systems are built to last a lifetime. They require a minimum of maintenance. Settings are changed infrequently. But when a change is required, this switch must operate smoothly and surely. To insure a long, dependable life, without freeze-ups or rust-outs, the manufacturer equipped it with a Curtis C-646 1" O.D. Stainless Steel double universal joint.

This kind of dependability is the stock-in-trade of Curtis joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, continuous testing, inspection and quality control at every stage of manufacture — these are some of the things that make Curtis joints your most dependable buy.

14 SIZES ALWAYS IN STOCK
⅜" to 4"

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CURTIS
UNIVERSAL JOINT CO., INC.
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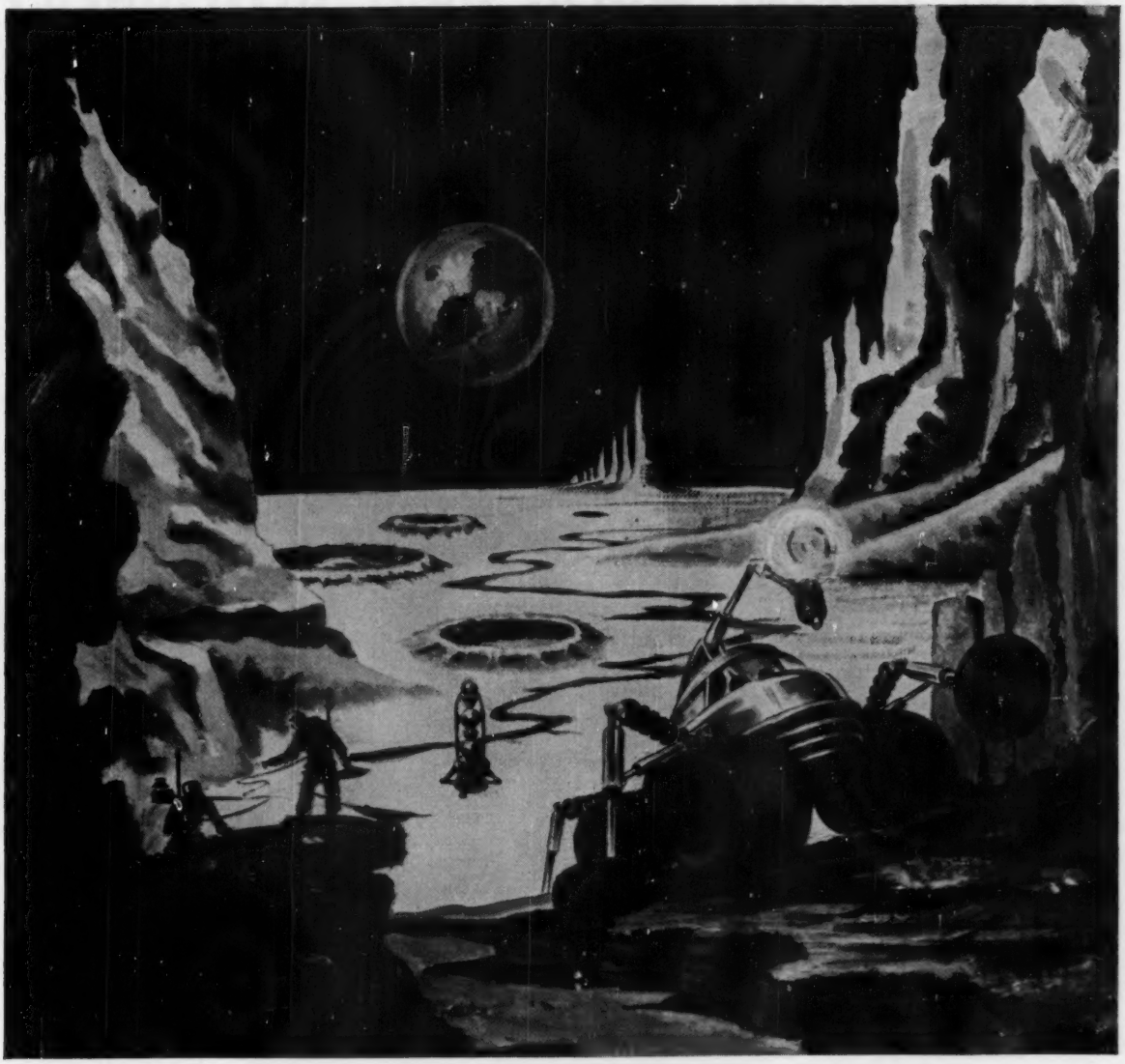
As near to you as your telephone. Exclusively a manufacturer of universal joints since 1919

Circle 563 on Page 19



Morse...frontiersmen in kinematics which works on earth or the moon!

Ready to help in the world of new ideas

Are your ideas bogged down by "do-it-yourself" development obstacles?

From the "think" stage through the full manufacturing responsibility, Morse engineers have earned their chevrons in the automotive and aeronautical fields for over 60 years. Their ideas can be most helpful in giving your ideas their needed boost.

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Let your design imagination go in the world of new needs!

Put the Morse powerhouse of supporting facilities backed by Borg-Warner's ultra-modern Roy C. Ingersoll Research Center on your team. The best way to start is by calling: Morse Chain Company, (Dept. 6-60), a Borg-Warner Industry, Ithaca, N.Y. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

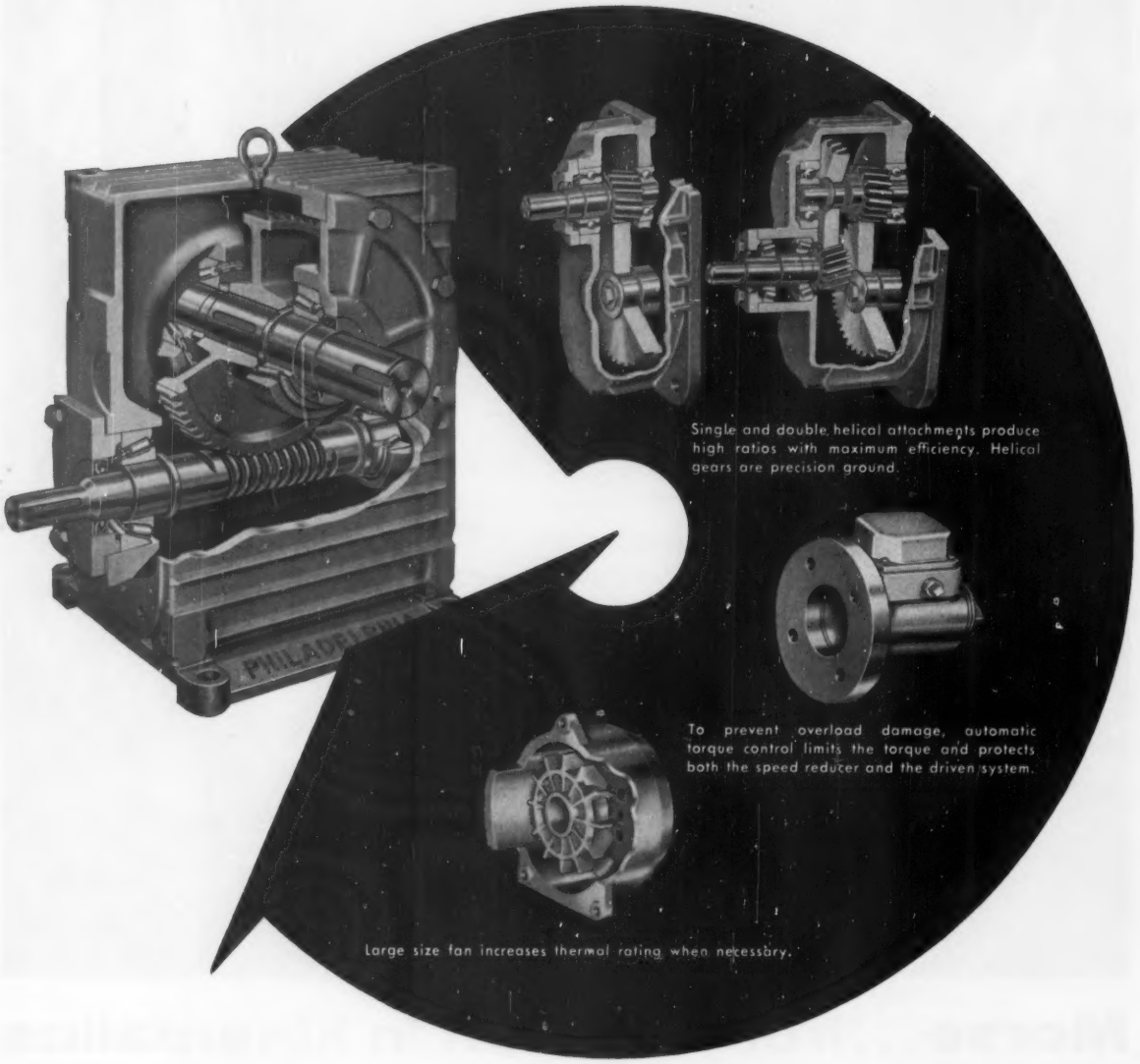
World's largest manufacturer of precision parts

MORSE BW

A BORG-WARNER INDUSTRY

Circle 564 on Page 19

Want higher worm gear efficiency?


Single and double helical attachments produce high ratios with maximum efficiency. Helical gears are precision ground.
To prevent overload damage, automatic torque control limits the torque and protects both the speed reducer and the driven system.
Large size fan increases thermal rating when necessary.

THEN HERE IT IS... FROM PHILADELPHIA

Here's new high efficiency in heavy duty worm gear drives that has never been available before. Helical attachments for double and triple reduction units combine the efficiency advantage of helical gearing with the high ratio advantage of worm gearing. You save on power... operating temperatures are lower... gearing lasts longer.

New high capacity, too. Improved tooth forms, precision ground alloy steel worms, special high strength bronze gears, heavy duty housings, precision ground helical gearing ... all add up to higher capacity in less space. In many instances you can save up to 50% in space, 40% in weight.

Delivery from stock of any drive arrangement and any mounting arrangement. Ratios from 5⅛:1 to 6150:1. Center distances: 3 in. to 21 in. Torque control attachments are also available from stock. For complete data, write for catalog WG-60.

philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Prussia, Pennsylvania (Suburban Philadelphia)

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

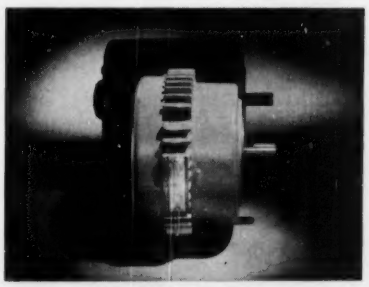
ball seating force from the top. **Tube Turns Plastics Inc.**, Louisville 11, Ky.

Circle 756 on Page 19

Thin Motor

has NEMA Type C face mounting

Thinline motor, designed for use on pumps, gears, and propeller-type fans, has NEMA Type C face mounting. Both dripproof and totally enclosed constructions are available in ratings from 1 through 5 hp at 1800 rpm, ¾ through 3 hp at 1200 rpm, and ½ through 2 hp at 900 rpm. New motor is as much as 7 in. shorter and 20 per



cent lighter than equivalent standard NEMA Type C face round frame motors. Frame and endshields are of rigid cast-iron construction. **General Electric Co.**, Schenectady 5, N. Y.

Circle 757 on Page 19

One-Component Adhesive

is high-strength, modified epoxy-resin type

Scotch-Weld EC-1595 is a one-component, modified epoxy-resin adhesive that permits easy application techniques and provides unlimited working life for bonding high-volume metal and plastic structural assemblies. Adhesive provides metal-to-metal bonds with shear strengths of 2500 psi at 75 F, maintains high strength over a service temperature range of −67 to +300 F, and exceeds requirements of MIL-A-5090B (Class A) and MIL-A-8431 (Type 1) specifications. It has high creep resistance under constant stress, exceptional adhesion to metals and plastics, and excellent resistance to water, 20 per cent salt spray, hydraulic oil, and aromatic fuel. Ad-

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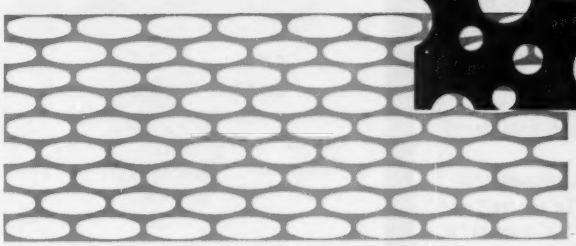

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Circle 566 on Page 19

On this Simple
Slotted Head Screw
OUR CUSTOMER
SAVED
OVER $20.00
per thousand pieces

with Redesign
for
COLD HEADING
by
CLARK

THE PROBLEM:
Cost of this special slotted head screw, when machined from bar stock by our customer, was considered too high.

SPECIAL REQUIREMENTS:
Head must be tapered and slotted. Thread gage must go to within 1½ threads of shoulder.

SOLUTION:
Production by Clark utilizing *cold heading* process.

SAVINGS TO CUSTOMER:
Over $20.00 per 1,000 pieces.

Send sample or blueprint for prompt analysis and quotation . . . at no obligation.

CLARK
BROS. BOLT CO.
MILLDALE, CONN.

Circle 567 on Page 19

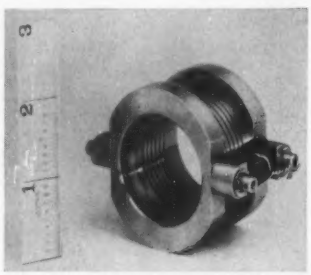
hesive is self-filleting which makes it excellent for honeycomb-sandwich construction. It can be applied by knife coating, spatula, notched trowel, or flowing into place. Film thickness of 2½ to 5 mils is desirable for optimum performance. **Adhesives, Coatings and Sealers Div., Minnesota Mining & Mfg. Co.**, 900 Bush Ave., St. Paul 6, Minn.

Circle 758 on Page 19

Bellows Assemblies

for high-temperature gas lines

High-temperature gas bellows assemblies are used in pairs. Assemblies allow 0.11 in. for 5 in. of angular offset movement to relieve the problem of expansion and contraction in the lines due to change in gas temperature. Bellows sections are machined bellows, designed for operating pressure of 1400 psig with gas temperatures to 1200 F. Material selection is determined by the specific application. **Hydrodyne Corp.**, 7350 Coldwater Canyon, North Hollywood, Calif.

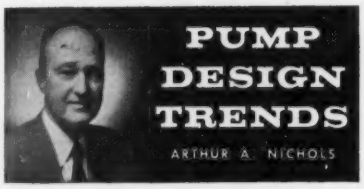


Circle 759 on Page 19

Coolant Pump

for machinery with shallow reservoirs

Gusher Model 9-P3 sealless pump is a flange-mounted type with one internal and two external discharges, right and left hand, respectively. Pump is designed primarily for machinery having comparatively shallow reservoirs. It will continue to pump until liquid level is at the extreme bottom of inlet port, minimizing possibility of air locking even with frothing liquids. Prelubricated, ball-bearing motor is 1/10 hp, with one-piece,



Lube and hydraulic systems are simplified with new "integral design" pump elements

Designers of machines employing lubricating pumps or low-pressure hydraulic systems can now achieve more compact design and reduced costs by integrating three matched Gerotor pump components directly into their mechanism. This space-saving innovation is now widely specified for machine tool, automotive, aircraft and other fluid systems.

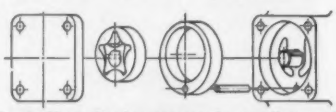


Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

Consisting of an inner and outer Gerotor and an eccentric locator-ring, the unit becomes a complete pump by simply boring the casting or frame of the mechanism to accommodate the locator ring. O.D. and by providing porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft. *(Fig. 1.)*

The matched elements are as easily built-in as a simple anti-friction bearing would be. Further, the Gerotor pump is extremely flexible in its configuration and readily adapts to a wide variety of mechanism geometries. It will handle a variety of fluids at rates up to 100 gpm and pressures up to 1,000 psi.

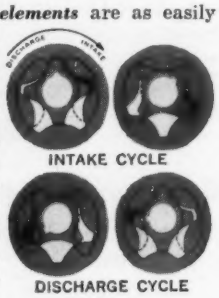


FIG. 2

The Gerotor pump is a positive displacement type, delivering a predetermined amount of fluid in direct proportion to speed. It is a form of internal gear pump — simple and compact in basic design, (has only two moving parts). It is lightweight, valveless, provides exceptional performance and has low wear over a long service life. It is balanced and extremely quiet in operation. *(Fig. 2.)* ***Investigate this cost saving development.*** Just send us information about the fluid you want to handle, rate of flow, pressure and dimensional limits. We'll provide specific recommendations, estimated costs and technical data.

W. H. NICHOLS CO.
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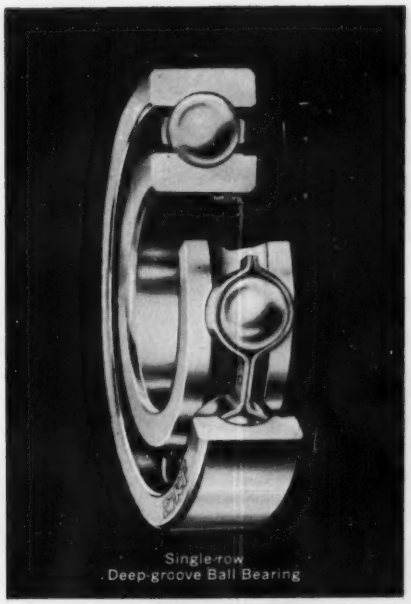
Circle 568 on Page 19



Can a standard bearing offer you "more bearing" for your money?

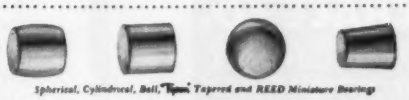
It can if it's made by SKF—because all SKF bearings, both ball and roller, offer special qualities at "production" bearing prices.

Take the single-row deep-groove ball bearing featured here, as an example. SKF designs and builds this type to sustain heavy radial load and thrust load in either direction. Furthermore, it is engineered to run smoothly and quietly at normal speeds with grease lubrication—and at high speeds with oil.

Yet this is a standard SKF ball bearing, mass-produced by automated production equipment at our plant at Altoona, Pa. You can quickly get this bearing in over 100 sizes, ranging from 5/8" to 15.748" O.D., and in a variety of seal, shield and snap-ring combinations.

But why not find out what SKF offers in bearing quality, availability and economy? Just call the SKF branch office nearest you.

6001



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EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES INC., PHILADELPHIA 32, PA.

Circle 569 on Page 19

Chace THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT

J-LINE

GAS-FIRED FURNACE

SAFETY PILOT

A PRODUCT OF JANITROL HEATING AND AIR CONDITIONING, A DIVISION OF MIDLAND-ROSS CORP. COLUMBUS 16, OHIO

When Janitrol designed the new J-LINE gas-fired counter-flow furnaces for basementless homes, they aimed at producing equipment to meet the highest contemporary standards for performance, economy and dependability. Precision-built throughout, the J-LINE models feature slim-trim styling, compactness, factory fire-testing, "deep well reservoir" pre-lubricated sintered bronze bearings for blowers, safe, sure, positive controls, acoustical insulation and, of course, a new safety pilot incorporating Chace Thermostatic Bimetal. The action of this sensitive bimetal element prevents the flow of gas to the pilot and the main burners should the pilot light be extinguished.

Here again is an example of precision control making an appliance so thoroughly safe that it is installed without hesitation by hundreds of thousands of contractors and home owners, usually close to the center of the living area itself. Janitrol buyers know that gas is the cleanest and *safest* of fuels because of Janitrol's specialized skill and experience in building home comfort equipment to highest quality standards for over half a century. Chace, too, has concentrated for over a third of a century on the development and manufacture of one outstanding product, precision thermostatic bimetal for thousands of applications — temperature control and indication and equipment protection. That's why Chace customers *know* their names are safe on the "outside" with Chace bimetal "inside."

If your *new* product is approaching the design stage, send for "Successful Applications of Chace Thermostatic Bimetal." It contains illustrations and design data on more than 30 types. Remember, too, Chace bimetal is available in strips, coils and in completely fabricated elements of your design.

W. M. CHACE CO.

Thermostatic Bimetal

1616 BEARD AVE., DETROIT 9, MICH.

IT BENDS WITH THE HEAT

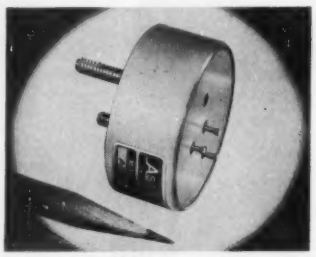
balanced shaft into the pump. There is no metal-to-metal contact within impeller housing. Pump develops a maximum pressure of 10 psig; capacity is 4 gpm at 9 psig and 27 gpm at 1 psig. **Ruthman Machinery Co.**, 1800 Reading Rd., Cincinnati 2, Ohio.

Circle 760 on Page 19

Pressure Switch

has very high sensitivity

A-21 pressure switch attains unusually high sensitivity by means of a stretched diaphragm pressurized by dry nitrogen. Solid Paliney contacts provide simple, rugged, dependable operation. Potential applications include aircraft-cabin pressurization protection, missile arming, initiating events at preset or programmed altitudes, and many



industrial-control system uses. **Astromics, Div., Mitchell Camera Corp.**, 611 W. Harvard St., Glendale, Calif.

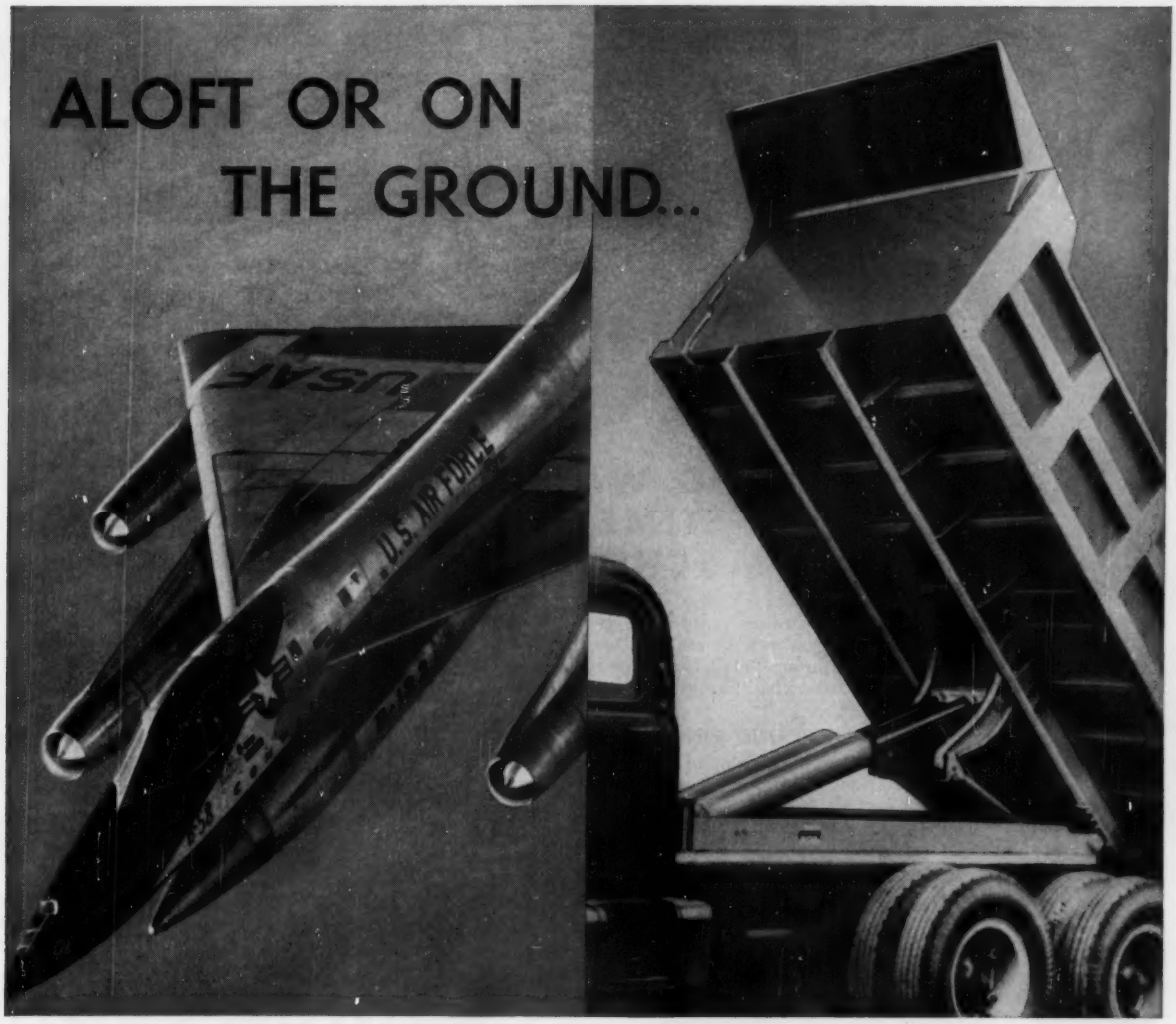
Circle 761 on Page 19

High-Heat Paint

for temperatures as high as 1700 F

Heat-Rem H 170 is available in 18 high-heat-resisting colors. Depending on the shade used, it permits color coding or complete finishing of metal components subjected to temperatures from 600 to 1700 F. Colors contain a combination of

Circle 570 on Page 19



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A Koppers Sealing Ring is applied to a B-58 actuator.

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Engineered from solid tool steel, WAPAK Hardened Ways are uniformly hard through and through . . . No galling, scoring or other failure throughout lifetime of your machines . . . even under rugged service. Carburized or laid steel ways also available in some sizes.

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nonleafing aluminum and a metallic pigment. Aluminum particles remain equally distributed and in constant suspension with the pigment, providing uniform coverage in the applied coat. Finish is resistant to moisture, corrosion, mild acids, alkalies, and industrial fumes. Paint is available in quart and 1 and 5-gal cans. **Speco Inc.**, 7308 Associate Ave., Cleveland 9, Ohio.

Circle 762 on Page 19

Multiturn Potentiometer

has continuous slide-wire resistance element

Infinite resolution multiturn potentiometer for instrument and instrumentation applications is designated Type IR-150. It features a continuous slide-wire resistance element, giving it the advantages of wire plus

infinite resolution. Resistance tolerance on the standard unit is ±10 per cent, and linearity tolerance is 0.5 per cent. The 2.7-oz potentiometer operates in a temperature range of −55 to 100 C and is available from 2 to 35 ohms. **International Resistance Co.**, 401 N. Broad St., Philadelphia 8, Pa.

Circle 763 on Page 19

Instrument Motor

for remote positioning and control applications

RBC-2410 low-inertia instrument motor provides unusually high starting and running torques, coupled with low-coast (when de-energized) characteristics required in most remote positioning and control applications. Available with heavy-duty gear reductions from 4:1

Circle 572 on Page 19

Circle 573 on Page 19→

For hazardous locations...

Specify ALLEN-BRADLEY

COMBINATION STARTERS IN SPIN-TYPE ENCLOSURES

Here's Allen-Bradley's Bulletin 713 combination starter with circuit breaker—featuring conveniently removable spin-type cover and base—for use in hazardous gas and dust locations. Inside you'll find the time-tested A-B Bulletin 709 solenoid starter.

The consistent reliability of Allen-Bradley solenoid starters is a result of their design simplicity. With only ONE moving part, there's virtually nothing to go wrong—this is your assurance of millions of trouble free operations. In addition, the double break, silver alloy contacts are *always* in perfect operating condition—and remain so with *no* service attention. Also, all A-B starters have two permanently accurate thermal relays that protect motors against dangerous overloads. The reliability of these relays is not affected by atmospheric conditions.

To insure maximum production with minimum maintenance, always insist on Allen-Bradley *quality* motor control. Please write for full information.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

9-10-58

Cutaway of Enclosure
Shows Allen-Bradley combination starter. Screw-type cover and base permit quick access to the starter or the circuit breaker.

A-B Bulletin 713
Combination Starter

NEMA 4
Watertight Weatherproof

NEMA 7
Hazardous Gas Locations

NEMA 8
Corrosive Hazardous Gas

NEMA 9
Hazardous Dust Locations

These enclosures remain available. Because of the trouble free operation of Allen-Bradley control, bolted covers are not a problem.

ALLEN-BRADLEY

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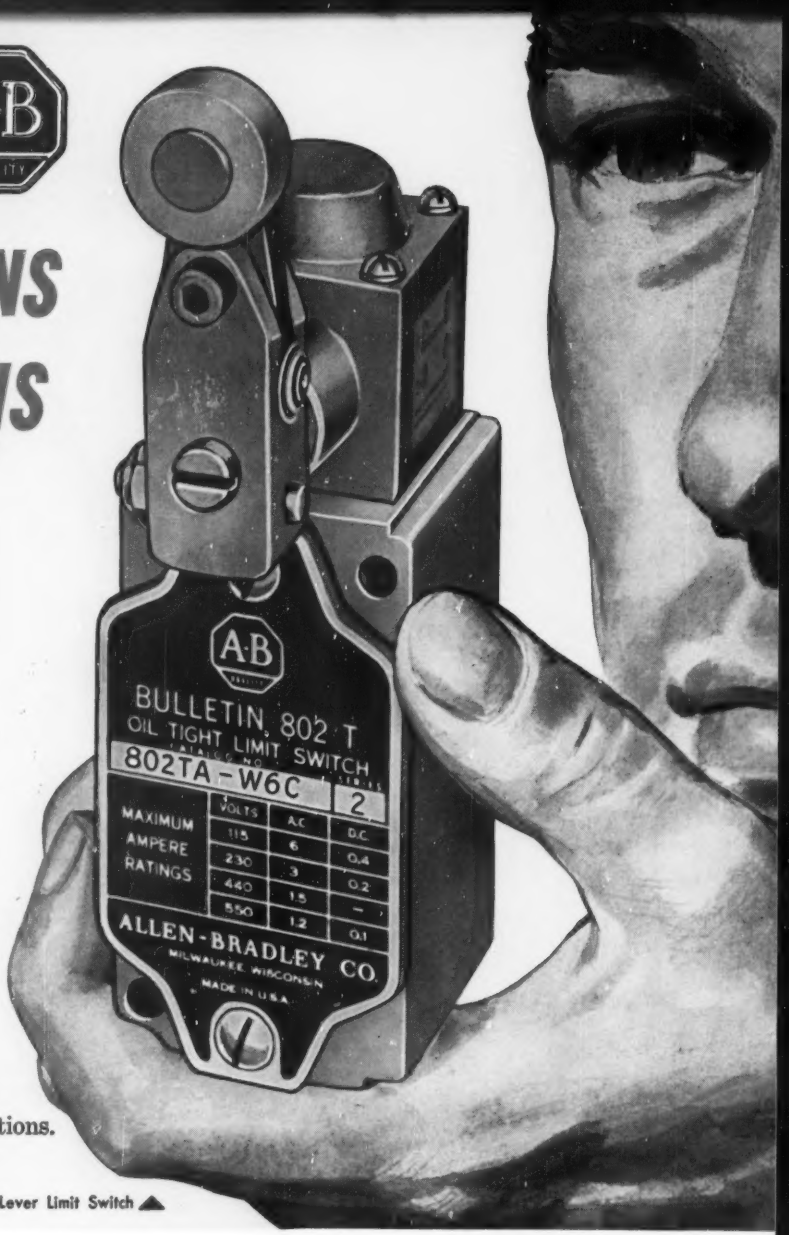
Quality Motor Control

MORE MILLIONS OF OPERATIONS

with Allen-Bradley Limit Switches

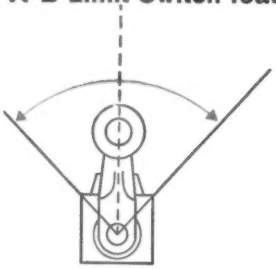
There's nothing now on the market to match the reliability and trouble free performance of Allen-Bradley Bulletin 802T limit switches. They are completely oiltight—operating heads and switch bodies are sealed against oils, coolants, and metal chips. Operators cannot become sluggish or "stick" in operation—contacts cannot become fouled. The double break, silver contacts are always in perfect operating condition—and remain so without maintenance.

Insist on Allen-Bradley—the *quality* line of limit switches that will give you *many more millions* of trouble free operations.

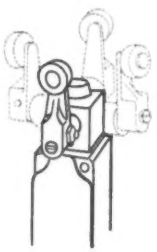


Bulletin 802T Micrometer Adjustment Roller Lever Limit Switch ▲

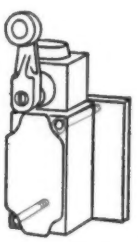
A-B Limit Switch features mean more life, more dependable trouble free service

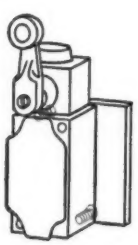


REPETITIVE ACCURACY—Unique toggle blade action assures operation at precisely the same point each time, without adjustment.



FLEXIBILITY—All operating heads can be rotated and fastened in any of four positions 90° apart.





FRONT MOUNTING **REAR MOUNTING**

All Allen-Bradley Limit Switches can be mounted either from the front . . . or from the rear.

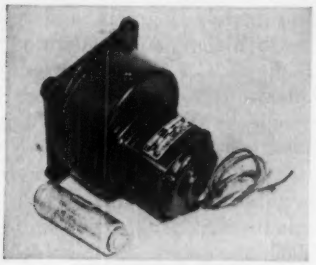
B-60-RH

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL



to 1800:1, total space required by motor and gear case, without output shaft, is 4⅛ x 4⅛ x 4⅝ in. Typical performance ratings are 750 oz-in. minimum starting torque and 350 oz-in. running torque at 6 rpm and 50 per cent intermittent duty. **Holtzer-Cabot Motor Div., National Pneumatic Co. Inc.**, 125 Amory St., Boston 19, Mass.

Circle 764 on Page 19

Glass Laminate

is now available in thicknesses to 2 in.

Glass-silicone laminated plastic Grade G-7, made with a glass fabric reinforced with silicone resin binder, is now available in sheets up to 2 in. thick. Laminate has extremely good dielectric loss factor and insulation resistance properties under humid conditions, plus excellent heat and arc resistance. Sheet size of random 24 x 36 in. is now offered in thicknesses from ¼ to 2 in. Grade G-7 sheets of 36 x 36-in. size are offered in thicknesses of ¼ in. and less. **Synthane Corp.**, Oaks, Pa.

Circle 765 on Page 19

Bimetal Disc Thermostats

can be furnished with 1 to 4 F differentials

Certified Type MX bimetal disc thermostats are available with differentials of 2 to 6 F in standard units and 1 to 4 F on special order. Close differentials and snap-acting feature provide a high degree of temperature control for electrical and electronic devices. Weight is

←*Circle 573 on Page 19*

"We recommend Banc-Lok tapped holes *for attaching surface hardware to all of our hollow metal doors and frames. Easy to install, they provide more than sufficient holding power for the installation and function of heavy-duty hardware",*

says E. A. Mauthe, Chief Engineer of the Building Products Division of American Welding and Manufacturing Company.

Laboratory tests conducted by Amweld convinced them of Banc-Lok's superior holding power. A test sample mounted with Banc-Lok tapped holes was subjected to a tension of 800 pounds, at which point the steel sheet itself began to bulge, but the Banc-Loks held firm. Such strength makes it possible for Amweld to eliminate costly reinforcement on 16 and 14 gauge frames. Amweld finds Banc-Loks "quick, simple, inexpensive and trouble-free".

Wherever screw threads with locking action are required Banc-Lok solves the fastener problem. Of one piece construction with no external threads, Banc-Loks are merely pressed into a prepared hole in a single operation, without special tools or extra locking devices. Find out how Banc-Loks can improve your product, save money—WRITE FOR OUR NEW CATALOG.

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36 Newtown Turnpike, Norwalk, Conn.
VI 7-2727 TWX NWLK 95-U

BOOTS-WESTERN
432 North Lake Avenue, Pasadena, Calif.
MU 1-6679 TWX PASA CAL 7255-U

Circle 574 on Page 19

Sealing Corrosives?

Teflon* Gaskets and "O" Rings Definitely Reduce Costs

... last for the life of the connection even in services such as concentrated acids, alkalis or solvents (except molten alkali metals).

... permit easy joint breaking without tearing or pulling—eliminate replacement cost and lost maintenance time for refinishing flange surfaces.

... can be used again and again—assure decided savings where joints must be frequently broken for cleaning and inspection.

Reduce *your* corrosive sealing costs with John Crane Teflon Gaskets, "O" Rings and Back-Up Rings. They are available in a full range of types and sizes, envelope or solid, also specials to specification. Request Catalog P-327 for complete facts.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

**DuPont Trademark*

John Crane — MECHANICAL PACKINGS — SHAFT SEALS — TEFLON PRODUCTS — LAPPING MACHINES — THREAD COMPOUNDS

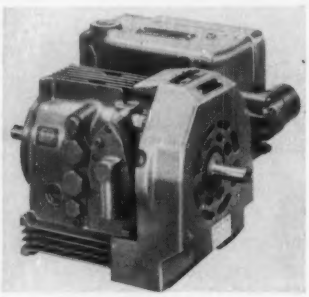
CRANE PACKING COMPANY

approximately 5 grams, and resistance to high g accelerations meets MIL-E-5272C. Several styles are available, either in semienclosed or hermetically sealed types. Ratings depend on duty cycle as well as the number of operations required. Thermostats are rated, based on noninductive load, at 3 amp for 25,000 operations, 30 v ac/dc and 115 v ac, to 1 amp, same voltage, for 250,000 operations. **Stevens Mfg. Co. Inc.**, P. O. Box 1007, Mansfield, Ohio.

Circle 766 on Page 19

Heavy-Duty Transmissions

convert constant-speed input into adjustable output speed



New Any-Speed transmissions for heavy-duty industrial service convert any constant-speed input power into an infinitely adjustable output speed. One or more adjustable speeds can be preset and selected, depending on choice of integral control devices, in one or both directions up to 1650 rpm. Designed for applications of 1 hp or less, units consume power only in proportion to work performed. There are no restricted flow or directional control valves used. Input speed is 1750 rpm, and output speed at normal torque is variable up to 1650 rpm. Starting torque is 62 lb-in., normal torque is 45 lb-in., and peak torque is 67 lb-in. **Oilgear Co.**, 1570 W. Pierce St., Milwaukee 4, Wis.

Circle 767 on Page 19

Rolled Epoxy-Glass Tubing

has properties of NEMA G-11 sheets

Dilecto GB-125EFR rolled tubing is made from epoxy resin-impregnated glass cloth that is rolled and cured on mandrels. Tubing is designed for

. . . FAST, UNIFORM PROCESSING — 1965 . . .

CAMBRIDGE METAL-MESH BELTS are the answer to the big problems you'll face in the competitive 60's—tighter operating costs, higher production and consistent quality.

Continuous movement of foods, metal parts, ceramics or chemicals on Cambridge Belts through processing operations speeds production and eliminates costly manual handling. Open mesh construction allows heat, cold or liquids to flow through the belt and around the product for thorough, uniform treatment. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs.

Belts can be made heatproof, coldproof or acidproof — in any mesh, weave, metal or alloy — with any side or surface attachments.

Have your Engineering Department call the Cambridge Field Engineer in your area. He'll be glad to discuss any aspect of Cambridge Belts — from manufacture to installation and service. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

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Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

Hobbs INDUSTRIAL HOUR METERS

Basic source for FACTS

UTILIZATION

— tells at a glance in hours and minutes the percentage of available time equipment operates . . . gives the complete picture of the work load requirements, production potential, need for additional equipment. Sets up a sound basis for leased equipment, service contracts, and the sale of used equipment.

MAINTENANCE

— enables the establishment of maintenance schedules on hours of use . . . the organized plan that saves money without cutting quality. Protects equipment and avoids costly interruptions in production schedules.

• Distributors in Principal Cities
WRITE FOR CATALOG 600

ALTERNATING CURRENT METERS available in 2½" and 3½" models in Bakelite case conforming to applicable government specifications. DIRECT CURRENT meters also available.

HOBBS PRESSURE SWITCHES

Industry-approved for wide range of applications. Single circuit, dual circuit; single terminal, double terminal — a complete line.

John W. Hobbs Corporation
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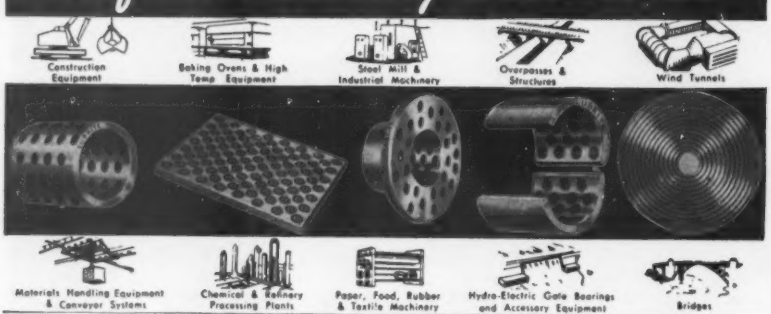
Symbol of SW Excellence

Circle 578 on Page 19

ASSURED SELF-LUBRICATING SECURITY WITH LUBRITE® Self-Lubricating BEARINGS


Construction Equipment
Baking Ovens & High Temp Equipment
Steel Mill & Industrial Machinery
Overpasses & Structures
Wind Tunnels
Materials Handling Equipment & Conveyor Systems
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Hydro-Electric Gate Bearings and Accessory Equipment
Bridges

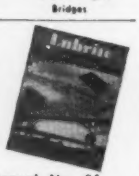
Lubrite self-lubricating bearings offer great versatility in hundreds of fields where dependability and superior performance are of prime importance.

Lubrite Bearings, with clean, permanent, maintenance-free self-lubrication are designed to withstand severe loadings, temperature extremes, submersion, corrosion and other adverse conditions.

Lubrite may be just the bearing you need in your designs to obtain better results.

Consult our Engineering Department on your application. No obligation.

Send for this free 20-page Lubrite Manual No. 55 — it contains complete information, technical data and specifications about Lubrite Self-Lubricating Expansion Plates and Bushings. Write today!



Available soon — New Manual No. 56 with complete technical information about LUBRITE SELF-LUBRICATING BUSHINGS, BEARINGS & WASHERS.
Write for your copy.

LUBRITE DIVISION
MERRIMAN BROS., INC.
188 AMORY STREET, BOSTON 30, MASSACHUSETTS

Circle 579 on Page 19

use in transformers and other heavy electrical equipment and for use in military electronic equipment. It features excellent physical properties, flame retardance, arc resistance, and high flexural strength at 150 C. Tubing is available with 3/16 to 12¾-in. ID and ¼ to 13½ in. OD with minimum wall thickness of 1/32 in. Tubing length is 38 in. **Continental-Diamond Fibre Corp.**, Newark, Del.

Circle 768 on Page 19

Solenoid Valves

have direct lift action

Series 1500 solenoid valves insure reliable operation regardless of pressure drop or flow conditions, through use of direct lift action and full-ported construction. Bubble-tight, leakproof, and packless, valves are designed for pressures from 0 to 1500 psi and for temperatures from −350 to +450 F. Low in cost,

they are available in bronze or stainless steel in ¼ to 1-in. pipe sizes. **Atkomatic Valve Co.**, 545 W. Abbott St., Indianapolis, Ind.

Circle 769 on Page 19

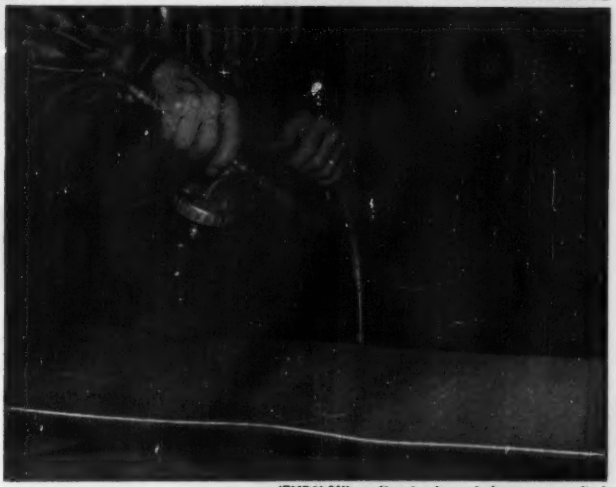
Rotary DC Solenoids

provide high torque and precision rotary motion

Rotary dc solenoids, available for applications where a combination of high torque and precision rotary

NEW *EMRALON*® TFE COATINGS SOLVE HEAT SENSITIVE APPLICATIONS

Acheson's resin-bonded tetrafluoroethylene (TFE) surface coatings are finding ready acceptance among design engineers. Where previous limitations of pure TFE prevented its application on heat sensitive substrates, because of its 700° F. sintering temperature, 'EMRALON' coatings are being successfully used on rubber, light metals, woods, and plastic. One such impressive case history is outlined here.



'EMRALON' coating is shown being spray-applied on woven belting with conventional equipment.

OVER $15,000.00 ANNUAL SAVINGS PROJECTED BY PROMINENT TIRE MANUFACTURER

Dunlop Tire and Rubber Corporation, Buffalo, N. Y., estimates this considerable savings in down-time costs alone on the basis of nearly nine months production use of an 'EMRALON'-coated belt conveyor. The particular belt involved is thirty feet long. Its importance in this company's tire production is emphasized by the fact that it is located at the point of a previous bottleneck. Rubber strips, conveyed from a series of masticating mills to an extruding press, formerly became stuck to the belting of this short-run conveyor immediately above the final masticator. The reason: the temperature of the rubber is elevated — through friction of the masticating process — to between 150° F. and 300° F. at this point. Belts had to be replaced anywhere from once every several hours to every six weeks. It was not unusual to have two or three stoppages every shift. The result: with the supply of rubber temporarily cut off, the entire department shut down. Costs ran $5.00 a minute, and with these work stoppages averaging 20 minutes each, the accumulated expense became prohibitive. Since April, 1959, the new belt has been in constant operation at this critical point in the masticating line.

To date it has not been removed from the mill . . . ample proof of the extraordinary non-stick, adhesion and flexing qualities of its 'EMRALON' coating!

The woven conveyor belt is a product of Globe Woven Belting Company, Buffalo, N.Y. Application of Acheson's 'EMRALON' to their belting was the outcome of a continuing research program headed by Globe Research Manager, Fred Kohlhagen. It is applied by standard commercial spray equipment to a film thickness of 0.7 mils and then oven-cured at a temperature of 300° F.

According to Mr. Kohlhagen, "This example will be only one of many success stories told about this coating. 'EMRALON'-coated belting can be used anywhere a slick, non-corrosive belting is needed. Those in the baking, canning, food processing, food packaging, and rubber fields should find immediate use for it." We might add that there are many other industries finding it advantageous to use 'EMRALON' . . . yours quite possibly is one of them. Why not write today for further information?

'EMRALON' — coated conveyor belt carrying hot rubber through masticating mill.

'dag' is a trademark registered in the U. S. Patent office by Acheson Industries, Inc.

'EMRALON' ADVANTAGES PROVED IN MANY LIGHT-LOAD USES

The growing list of production applications for the new Acheson 'EMRALON' surface coatings, is convincing proof of their versatility. That film pack, office machine, and lock mechanisms; rubber molds and oil seals; bakery dough handling equipment and countless other light load, solid-film lubrication problems have successfully been answered, is now a matter of record.

With 'EMRALON' 310* — colloidal TFE in a phenolic resin solution — a one-hour cure at 300° F. is all that is necessary. And, for substrates even more sensitive to heat, 'EMRALON' 320** colloidal TFE in a thermo-plastic resin carrier — is available. Both provide excellent adhesion, low coefficient of friction, flexibility, toughness, and corrosion resistance. Applied by conventional paint spray equipment, they allow easy production line conversion to 'EMRALON' solid-film lubricants.

'EMRALON' coatings represent the latest in a long line of widely accepted Acheson products, one of which may offer a ready-made answer to your particular lubrication problem. We welcome the opportunity to be of service. Send for your copy of our Products List which outlines the full line of Acheson Dispersions. Address Dept. MD-60.

*'EMRALON' 310 is manufactured under exclusive license from E. I. duPont deNemours & Company (Inc.) under U. S. Patent 2,825,706. Not licensed for use or for sale for use in providing electrical insulation.

**'EMRALON' 320 — patent applied for.

ACHESON

dispersions digest reporting uses for

dag® BRAND DISPERSIONS

ACHESON *Colloids Company* **PORT HURON, MICHIGAN**

A division of Acheson Industries, Inc. Also Acheson Industries (Europe) Ltd. and affiliates, London, England

Offices In:

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Slots (or corrugations) prevent Fastener from turning.
Sheet remains flush on opposite side. No swaged rim projects.
Clinching ring squeezes sheet material around back-tapered shank, securely locking Fastener.

PEM

The ORIGINAL Self-Clinching Fastener

Fifteen years ago Penn Engineering and Manufacturing Company introduced the self-clinching fastener, providing load-bearing threads in a wide range of—steel, aluminum, brass and copper sheets, "too thin to thread."

THE ANSWER TO PRODUCTION FASTENING

This unique, exclusive design was immediately recognized as the answer to production fastening by leading manufacturers of aircraft and missiles, automotive, electronic and communication equipment, business machines, farm machinery, electrical appliances, transportation equipment, vending machines, home appliances, etc. Stimulated the cost-conscious sheet metal assembly techniques utilized, today, by many of these manufacturers.

INSTALLED BY A SQUEEZE *With the Greatest of Ease* (without special tools)

Users tell us that—because the shank of PEM nuts acts as their own pilot . . . because, being round, they require no indexing . . . because they require no special tools . . . because several may be pressed into place in a single operation . . .

THEY SAVE THEIR COST MANY TIMES OVER

. . . in time, labor and special equipment. PEM nuts are one of the most profitable items in the assembly line.

Today, PEM Self-Clinching Nuts are made in six types for sheet thicknesses from .03″ and up—in steel (with various rust resistant finishes), stainless steel, monel and aluminum. Sizes range from #2 to ¾″. Also made as Blind Fasteners for pressure seal applications.

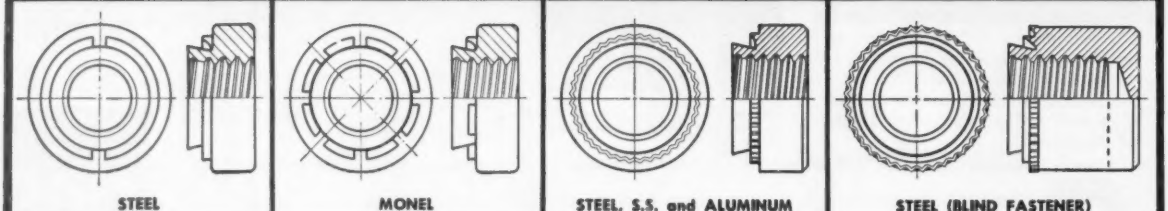
For complete information, write for Bulletin No. CL359.

HIGH TORQUE AND PUSH-OUT RESISTANCE

. . . greatly in excess of assembly handling and screw torquing requirements, insure smooth, fast, uninterrupted fastening procedure. In service, under working load and vibration, torque and push-out resistance are not reliability factors, since the screw is always pulling the PEM Nut toward the sheet into which it is fastened.

The smooth *reverse* side of the sheet, with no swaged rim projecting, permits flush-tight assembly without need for clearance hole in attached part.

SIX TYPES OF PEM SELF-CLINCHING FASTENERS ANSWER MOST ALL REQUIREMENTS



PENN ENGINEERING & MANUFACTURING CORP., DOYLESTOWN • PENNSYLVANIA

New York (Belle Harbor, L. I.)—Neptune 4-7103
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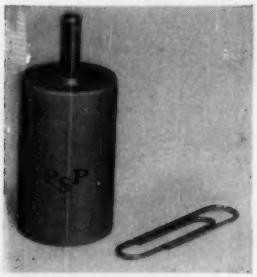
Detroit—University 3-5189
Milwaukee—Bluemound 8-6118
Dallas—Fleetwood 7-5713
Los Angeles—Bradshaw 2-8097
Miami—Tuxedo 5-3147



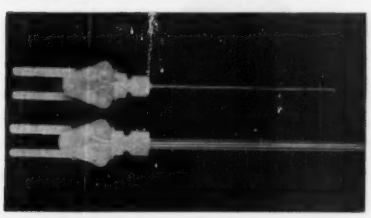
motion is desirable, provide reliable performance under severe operating conditions. Typical applications include operation in high-temperature environments, in pressurized mechanisms, and in aircraft or military systems requiring exacting performance. Units are also suited for installations where no axial travel of the output shaft can be tolerated, or where the rotary stroke may be externally stopped prior to completion of normal electromagnetic stroke of the unit. They are available in five sizes from 8 to 18, and can be supplied in any stroke length from 0 to 60 deg, clockwise or counterclockwise rotation. Operating voltages range from 6 to 300 v dc. **PSP Engineering Co.**, 6058 Walker Ave., Maywood, Calif.

Circle 770 on Page 19

Swage-Type Thermocouples

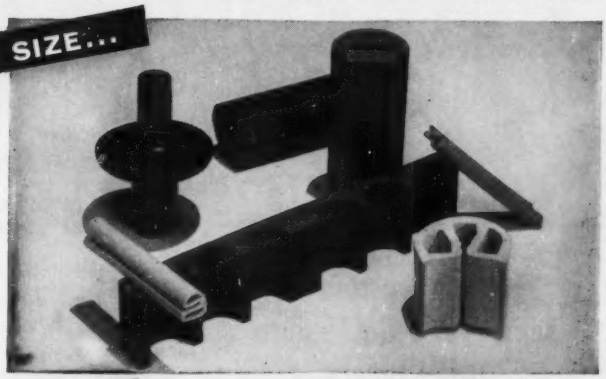
have electrical insulation to 2500 F

Fast-response, industrial-type thermocouples with swage design, called A+ thermocouples, are shock and vibration resistant. Thermocouples employ a precision-made, compacted, swaged M_gO-insulated design that provides outstanding electrical insulation characteristics to 2500 F. Swaged sheath maintains a constant wall thickness, even distribution of compacted M_gO mineral insulation, equidistant spacing of conductors, and uniform mass of hot junction. Withstanding pressures to 40,000 psi and made to ISA

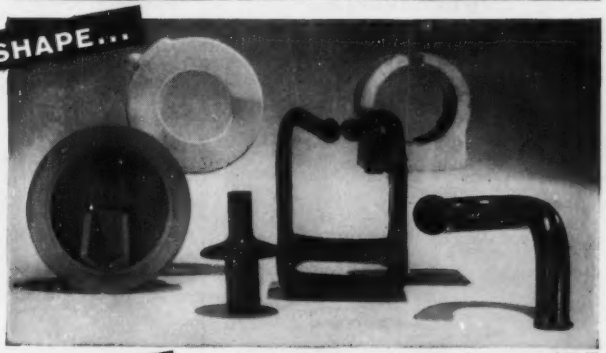


STALWART PRODUCES PRECISION CUSTOM RUBBER PARTS TO YOUR EXACT SPECIFICATIONS

ANY SIZE...

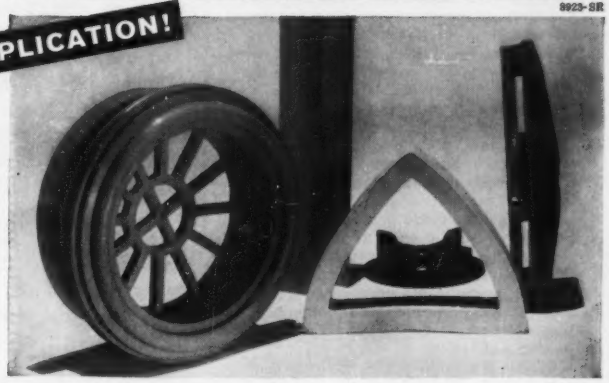


ANY SHAPE...



8923-SR

ANY APPLICATION!



Compounded from all types of natural and synthetic rubber, Stalwart custom parts are molded, extruded, cut, calendered, sponged or spliced to meet the most exacting performance requirements . . . as well as all standard specifications established by military and industrial organizations. Every Stalwart customer is assured of the highest quality plus important production economies . . . through modern production facilities, advanced compounding techniques and extensive testing facilities. Write us today about your special rubber parts problem or check with Stalwart's Plastics Division for injection molded parts to meet your requirements.

THE WORLD'S LARGEST PRODUCER OF SILICONE CUSTOM RUBBER PARTS

STALWART RUBBER COMPANY

Send for your copy of the new Stalwart Catalog.

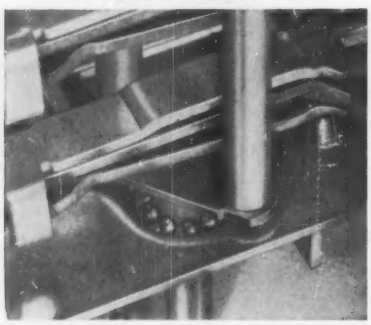
180 Northfield Road
Bedford, Ohio
Subsidiaries: Jasper Rubber Company
Warren Molded Plastics, Inc.

Circle 582 on Page 19

ABBOTT

PRECISION-QUALITY BEARING BALLS

are indispensable to the proper function of sensitive, reliable auto radio tuners



To uphold its redoubtable reputation as a communications specialist, a leading manufacturer of automotive radio systems must be certain that every component used in its assemblies performs reliably.

For example, when this auto tuner assembly is coupled to the electrical system, it must provide positive location and low torque to ensure fine tuning . . . and dependable, precision-quality bearing balls perform a vital function. The bearing balls provide uniform torque between the conical shaft and the bearing race, without introducing tortional strain and undesirable angular displacement . . . and customer requirements for life expectancy and non-degradation in function of the complete assembly are repeatedly satisfied.

Abbott precision-quality bearing balls adapt easily, perform reliably, and last! A wide range of sizes is available. Write for complete information.

Write for copy of Bulletin AP-1

THE ABBOTT BALL COMPANY

118 RAILROAD AVE. HARTFORD 10, CONN.

ABBOTT the Leader since 1909 1909-1960

Circle 583 on Page 19

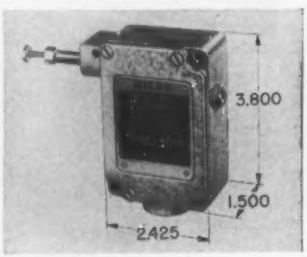
standards, thermocouples are available in a variety of materials, calibrations, and connections to meet numerous applications. **Atkins Technical Co. Inc.**, 1276 W. 3rd St., Cleveland 13, Ohio.

Circle 771 on Page 19

Snap-Acting Switch

for momentary opening and closing of a circuit

Pulse-producing snap-action switch, No. 1PD1, is designed for industrial applications where momentary opening and/or closing of a circuit is necessary. Switch is especially useful for controlling pneumatic valves



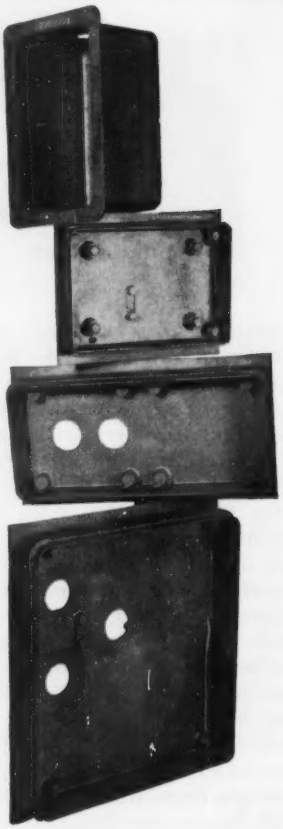
where permanent-duty solenoids are not used. Entire pulse operation occurs as plunger is depressed; no switching action takes place on plunger return stroke. Mechanical characteristics include 0.150-in. maximum pretravel; 0.600-in. minimum total plunger travel; 4-lb operating force and 8-lb full overtravel force. Pulse length is adjustable from 0.030 to 0.450 in., and adjustable plunger can be extended 0.750 in. Switch is sealed against oil, water, dust, and dirt. Electrical characteristics of the SPDT switch are 10 amp at 125, 250, or 480 v ac; ½ amp at 125 v dc; ¼ amp at 250 v dc. **Micro Switch Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill.

Circle 772 on Page 19

Gear Motor

in capacities from 1/12 to 2 hp

C-Flange gear motor is available in a wide range of capacities and reductions. Motor and reducer are separate, flange connected, so unit is furnished either as a complete assembly, or reducer alone will be supplied for application to standard NEMA motors. When drive condi-



Aluminum cans for electronic applications are cast accurate, smooth and pressure tight by the unusual foundry methods of Morris Bean & Company, Yellow Springs 2, Ohio.

BEAN

aluminum
magnesium
ductile iron
foundries

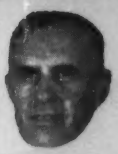
Circle 584 on Page 19

MARINE POWER

CONSTRUCTION POWER

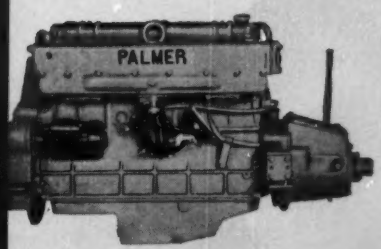
GROUND SUPPORT POWER

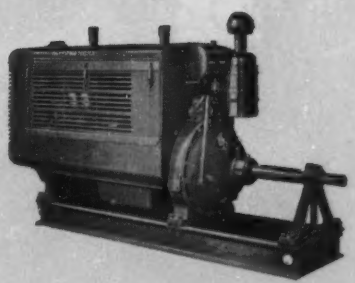
"Our sales have increased over 500% since we began using International engine assemblies five years ago." Report from R. C. Bolling, President, Palmer Engine Co.

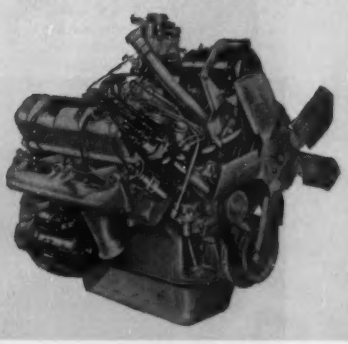


"International diesel engines meet our standards for efficiency, dependability and parts and service coverage." Report from Guy Banister, Chief Technical Engineer, Barber-Greene Co.

"The wide range of power in the International line fits in with our plans to offer a wide selection of models." Report from Roger Frantz, Design Engineer, Hobart—Motor Generator Corp.







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Efficient and dependable power is assured for products of leading engineers, who specify IH engines for a wide variety of applications. Design engineers serve many different industries, but they all have one common problem: to find the most practical, economical and efficient power for their products. If you have the responsibility for selecting the power for your products it will pay you to check International engines because—

FIRST, you have a wide selection of power from which to choose—35 engines from 16.8 to 385 max. hp—available in gasoline, LP gas, natural gas or diesel.

SECOND, IH engines meet rigid requirements of economy and dependability. Millions of hours of continuous operation in all parts of the world have job-tested International power on every heavy-duty application.

THIRD, your customers never have to wait for replacement parts. International's world-wide parts and service facilities back up your organization with fast assistance on power problems.

Check the complete line of IH engines now, and discover the extra selling advantages International power adds to your product. Call or write to International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

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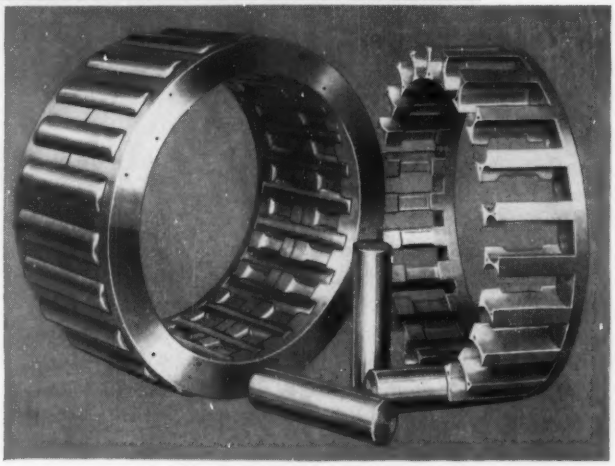
IH ENGINES

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Ill.

A COMPLETE POWER PACKAGE

Circle 585 on Page 19

The Cage...Heart of the MESSINGER Radial Roller Bearing



THE CAGE of a Messinger Radial Roller Bearing, large or small, is the real key to long bearing life with precision performance, especially at sustained high speeds.

Each Messinger cage is of a special rugged design developed by Messinger Engineers . . . made of highest quality bronze . . . machined all over with exacting care. Tolerances are held to amazing closeness.

The cage is a vital contribution to the ultimate in bearing longevity and reliability which Messinger Bearings provide.

Designing a new machine? Call on Messinger, now, for consultation. No obligation.

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ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

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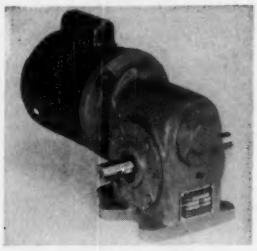
"Smoothing Industry's Pathway for Nearly Half a Century"



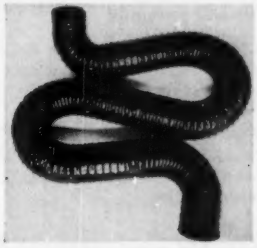
tions change, either motor or reducer can be changed without obsoleting the other element. Capacities range from 1/12 to 2 hp, reductions from 5:1 to 60:1. **Morse Chain Co.**, Ithaca, N. Y.

Circle 773 on Page 19

Glass Fabric Hose

has excellent flame resistance and high burst strength

Available for both permanent and temporary use in air-handling and fume-control applications, GlasHose is furnished in sizes from 1½ to 24 in. ID. Made of neoprene-coated glass fiber, it is spiral-wire reinforced. Lightweight and extremely flexible, hose has excellent flame resistance and high burst strength.



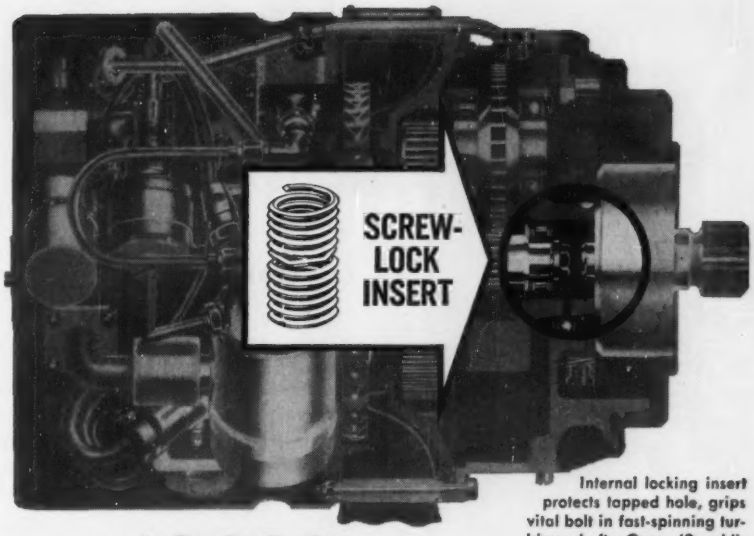
Operating temperature range is −40 to +300 F. **Flexaust Co.**, 100 Park Ave., New York 17, N. Y.

Circle 774 on Page 19

Motor-Generator

provides constant 60-cycle power

Combination electric motor and 60-cycle ac generator set provides a continuous source of 60-cycle ac power. Output is 10 kva and speed is 1760 rpm. In case of power-line failure, generator is driven by a gasoline or diesel engine which is automatically brought up to proper speed so that frequency dip will not exceed five or six cycles. Generators are powered with either single



Internal locking insert protects tapped hole, grips vital bolt in fast-spinning turbine shaft. Over 40 additional *Heli-Coil* Inserts insure threaded fastener security throughout the starter.

at 46,000 R.P.M.

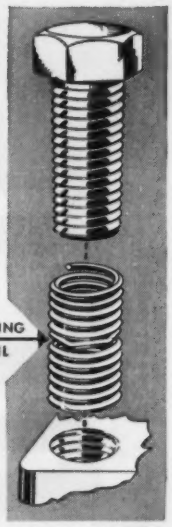
HELI-COIL®

SCREW-LOCK INSERT*

holds this vital bolt fast
...Without Lock Washers
or Lock Wiring!

Even when the turbine shaft of General Electric's new AS-18 turbostarter whirls at 46,000 rpm... the key bolt at the end of the shaft can't work or wear loose. General Electric puts a one-piece, *internal locking* **Heli-Coil** Screw-Lock Insert in this tapped hole, gets thread security in this important threaded assembly despite vibration met at high shaft speeds.

In addition to the critical shaft application, General Electric uses more than 40 of these ***Heli-Coil*** stainless steel wire inserts throughout this compact 165 hp starter for aircraft gas turbines. Production and performance benefits? Unshakeable fastener security *without* the use of clumsy, heavy lock nuts, lock washers and lock wiring... lighter weight... less installation cost... faster and easier assembly and disassembly of this tiny power pack that weighs only 46 pounds! *Patented



Principle of ***Heli-Coil*** Screw-Lock Insert. Locking center coil grips screw in tapped hole; holds screw firmly against vibration and impact.

Heli-Coil Screw-Lock Inserts

- positively lock screws and bolts against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- eliminate lock nuts, lock wiring, other supplementary locking devices
- can be used in standard proportion bosses without need for redesign
- are available in a complete range of U.N.C. and U.N.F. thread sizes
- save assembly time, space, weight and cost
- meet military specs for locking torque and vibration

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 506 Shelter Rock Lane, Danbury, Connecticut
Send complete design data on *Heli-Coil* Screw-Lock Inserts

NAME_____TITLE_____
FIRM_____
ADDRESS_____
CITY_____ZONE____STATE_____ 1772

In Canada: Armstrong Beverley Engineering Ltd., 6975 Jeanne Mance St., Montreal 15, Que.

Circle 587 on Page 19

AVAILABLE IN A COMPLETE RANGE OF SIZES AND WITH SINTERED BALLS

If you have applications involving linkage or transfer of motion, SPHERCO Bearings can supply your needs in a wide variety of materials with a quality that will give you top performance under normal or high temperature conditions.

WRITE FOR CATALOG 560

SPHERCO a product of SEALMASTER BEARING DIV.
STEPHENS-ADAMSON MFG. CO., 18 Ridgeway, Aurora, Ill.

"Precision built for superior performance"

SPHERCO®

BEARINGS & ROD ENDS

Circle 588 on Page 19

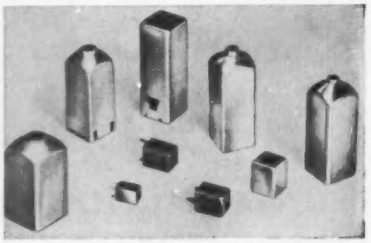
or three-phase induction low-slip motors. Regulation is by a magnetic amplifier mounted on collector ring or generator end. **Kato Engineering Co.**, Mankato, Minn.

Circle 775 on Page 19

Coil Cans

can be slotted, hole-punched, or shaped

New coil cans in basic designs are currently in production in sizes ranging from larger types to transistor dimensions as small as 1/4-in. diam. Series of basic models can be



slotted, hole-punched, or shaped to meet most electronic applications. **Staver Co. Inc.**, 49-51 N. Saxon Ave., Bay Shore, L. I., N. Y.

Circle 776 on Page 19

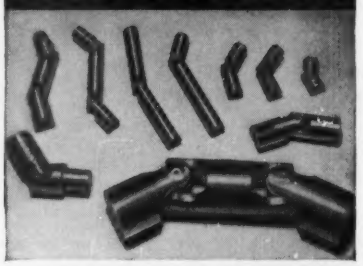
Copper-Clad Laminate

has high insulation resistance

Textolite 11577 copper-clad laminate has improved characteristics for printed-circuit applications. The self-extinguishing, epoxy, paper-base laminate surpasses any XXXP grade. It offers excellent cold punching and machining properties, high insulation resistance, and superior electrical characteristics. Laminate has 1 million megohms resistance at 35 C and twice the impact and flexural strengths of XXXP standards. It withstands cyanide-plating solutions and provides improved bonding strength between copper and laminate for increased circuit reliability. Peel strength is between 4 and 6 lb, higher than 1-lb peel strength called for in U/L specifications. Material is available in standard sheet sizes of 36 x 36 and 36 x 72 in. and ranges in thickness from 0.031 to 0.250 in. **General Electric Co.**, Schenectady 5, N. Y.

Circle 777 on Page 19

FAST DELIVERY FROM STOCK...



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UNIVERSAL JOINTS

26 STANDARD TYPES AND SIZES

- For all slow speed applications to 300 rpm.
- Single or Double Joint
- Horsepowers ½ to 207 at 100 rpm.
- Bores ¼" to 2", also furnished solid
- Standards can be altered to specifications
- Special types and designs furnished promptly

• Contoured yoke permits maximum operating angle of 45° for single joint, 90° for double • Highest quality hardened alloy steel throughout • Forks precision ground to within .001" concentricity • Pins ground to .0005" tolerances • Accurately intersecting holes in center blocks.

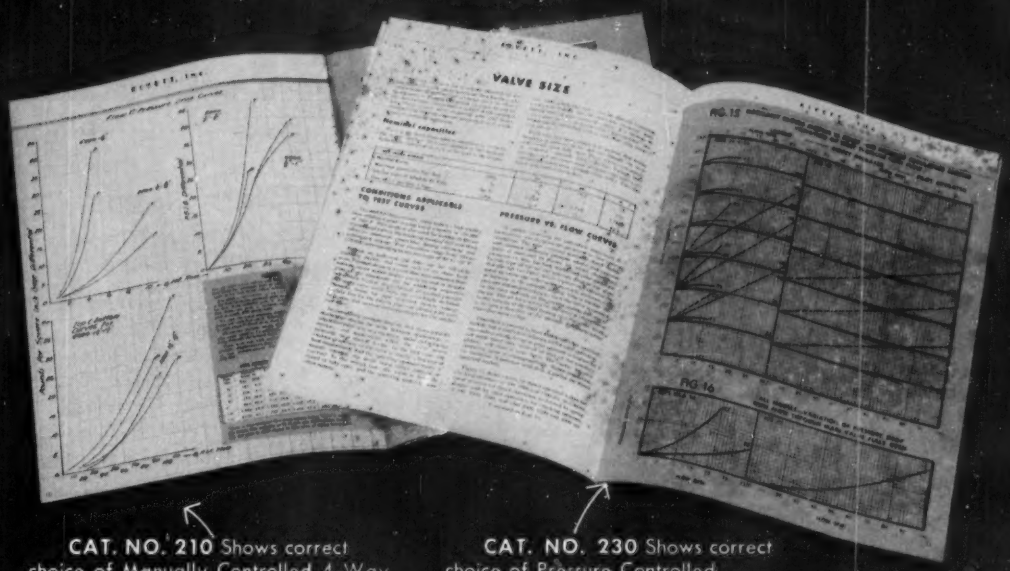
HOW TO GET THE EXACT UNIVERSAL JOINT FOR YOUR JOB...

Request handy Universal Joint Guide, Form 820F, and Bulletin 820.

LOVEJOY FLEXIBLE COUPLING CO.
4818 W. Lake St. • Chicago 44, Ill.

Circle 589 on Page 19

STOP GUESSING VALVE PERFORMANCE!



CAT. NO. 210 Shows correct choice of Manually Controlled 4-Way Hydraulic Valves

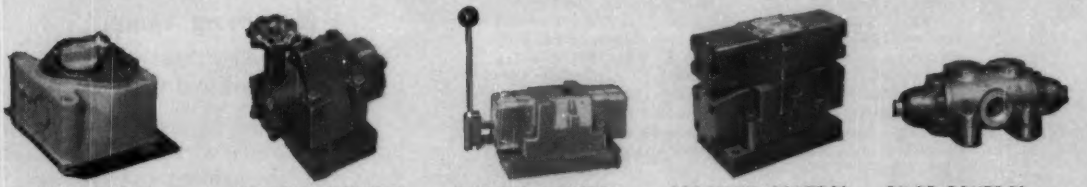
CAT. NO. 230 Shows correct choice of Pressure Controlled Hydraulic Valves

RIVETT Publishes The Facts So You Can Predict Accurately Pressure Drop In 4-Way and Pressure Controlled Hydraulic Valves!

Select your valves on facts, not guesses! The flow versus pressure drop curves shown in the catalogs above are based on actual tests. The curves make it possible to determine system efficiency and operating costs *before* you operate the circuit. Rivett's lower pressure drop means a lower cost to actually run your hydraulic systems. Before you specify the components for your next system, get the facts! Ask your Rivett dealer, or write for Rivett Catalogs 210, 230, 250 and 261 now.

RIVETT

Furnishes Complete Line of Hydraulic Valves — Over 400 Standard Models — 1500, 2000, 3000 P.S.I.—Sub-Plate and Pipe Mounted—¼" to 1½" Sizes—3 G.P.M. to 130 G.P.M.



FLOW CONTROL
Model 8622: 3000 P.S.I.; Sub-Plate Mounted. Four Sizes: ¼" to 1½". See Catalog 250.

PRESSURE CONTROL
Series 8800: Relief, Sequence, Unloading, Reducing, and Counterbalance. With and without check. See Catalog 230.

MANUAL CONTROL
Series 5000 and 6100: 4-Way. Hand, Foot, or Cam. Sub-plate or Pipe Mounted. ¼" to 2" sizes. 2000 and 3000 P.S.I. See Catalog 210.

SOLENOID CONTROL
Series 6500 and 6600: 4-Way. Direct or Pilot operated. ¼" to 1½" in three basic sizes. 3000 P.S.I. Low current. See Catalog 261.

PILOT CONTROL
Available in Solenoid, Pressure and Manual operations. ¼" to 1½" sizes. 1500, 2000 and 3000 P.S.I.

RIVETT

RIVETT, Dept. MD-6, Brighton 35, Boston, Mass.
furnishes a complete power package
AIR AND HYDRAULIC — VALVES, CYLINDERS, POWER UNITS
Member — National Fluid Power Association

Circle 590 on Page 19

TECHNICAL MEMO ON LINEAR COMPOUNDS 7441-50 & 7446-70

. . . for U-cups, O-rings and other seal configurations

- especially designed for service in hydraulic fluids, lubricating oils and automatic transmission fluids
- good recovery properties, excellent wear resistance
- fully effective sealing from −40° to +212°F; can be used intermittently to +325°F in oil

MATERIALS COMPATIBLE WITH THESE COMPOUNDS:

Alcohol • Corn Oil • Cosmoline 1056 • DTE Oil • Ethylene Glycol • Freon 11 • Freon 12 • G.E. #10 Transformer Oil • Gulf Pride • Gulf XB Grease • Hexane • Houghto-Safe 271 • Hydrolube • Lard • Larex • Lubricating Oils • Lubriplate • MIL-F-25558A • MIL-G-4343 • MIL-H-5606 • MIL-L-9000 • MIL-L-15016 • MIL-L-15017 • Mineral Base Hydraulic Oils • Mo Par Fluid • Olive Oil • Penzoil Trans Oil • Prestone • Sea Water • Shell #532 • Shell Iris 902 • Shell Donax T6 • Shell Northia #41 • Shell Tellus #33 • Shell Tellus #41 • Socony Vactra Oil • Sohivis • Soybean Oil • Suniso #4 • Suniso #7 • Sunoco Dynalube • Suntac #201 • Ucon LB-300X • Ucon 200 N • Univolt #35 • Velocite #1 • Water

For complete technical data—including list of incompatible materials—Request Bulletin 56703-1. Linear Inc., State Road and Levick St., Philadelphia-35, Pa.

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LINEAR Inc. STATE ROAD & LEVICK ST. PHILA. 35, PA.

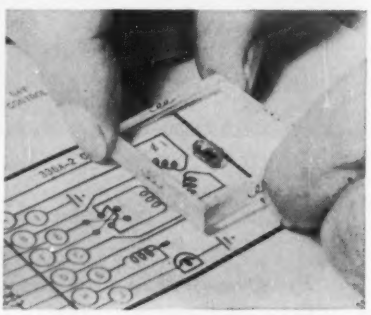
ENGINEERING DEPARTMENT

EQUIPMENT

Symbol Stamps

quickly reproduce drafting symbols

Called Symbostamps, transparent vinyl and lucite stamps fulfill a need for a timesaving, convenient method of reproducing thousands of industrial drafting symbols. Technical symbols for the fields of electronics, hydraulics, architecture, mechanical



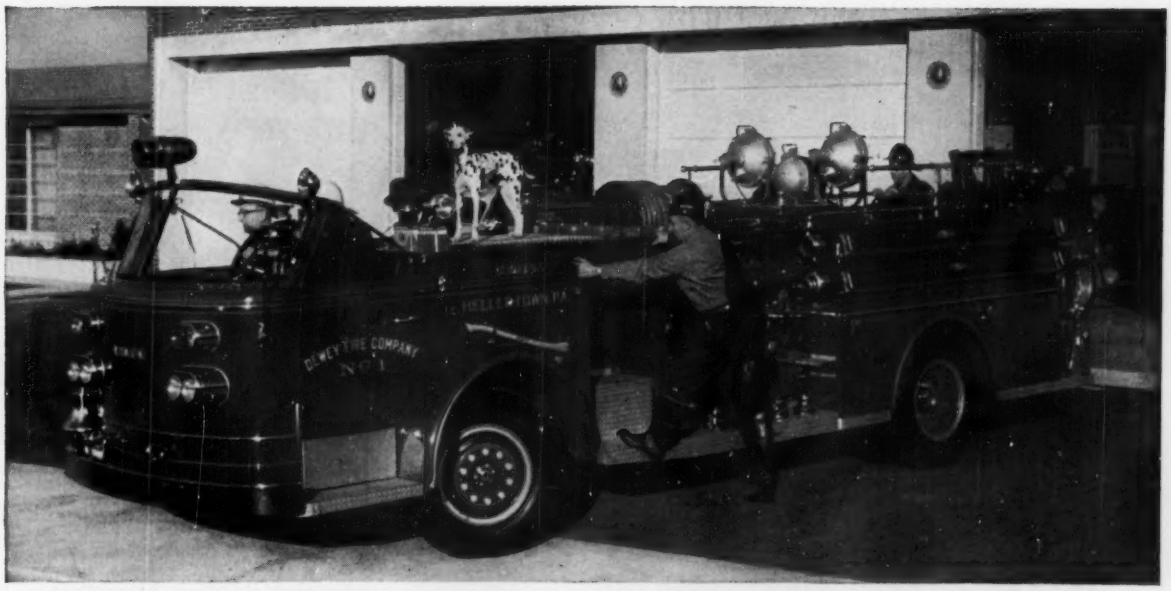
engineering, and electricity are immediately available. Any symbol or complex of symbols can be manufactured to specification rapidly and economically. Stamps offer ease of handling, perfect alignment, and excellent quality impressions for accurate reproduction. **John Griffin Co.**, 2117 Grand Ave., St. Paul 5, Minn.

Circle 778 on Page 19

Magnifying Viewer

provides three-dimensional viewing

Illuminated magnifying viewer for close tasks or viewing requiring bright lighting and full view magnification is known as Model DSV. It features a 6 x 6-in. optically ground acrylic lens that provides full three-dimensional perception. Two 4-w fluorescent tubes highlight working area, and soft, diffused underlighting is provided by two recessed 8-w fluorescents under viewing-table base. Underlighting and overhead light can be positioned separately by means of friction-collar



American-LaFrance pumper at Dewey Fire Co. No. 1, Hellertown, Pa.

Sheet Steel to the Rescue!

Who doesn't thrill to the flashing color and competent power of a modern fire engine roaring by on its errand of mercy?

Hard-working trucks like these need husky steel to safely haul their cargo of men and fire-fighting machinery. Bethlehem supplies hot-rolled and cold-rolled sheets to most of the makers of fire apparatus and fire-protection equipment.

If your product involves sheet metal, steel is the material with which to design and work. You can always count on Bethlehem sheet steel for top quality. Our engineers will be glad to work with you.

Steel

For strength
... economy
... versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

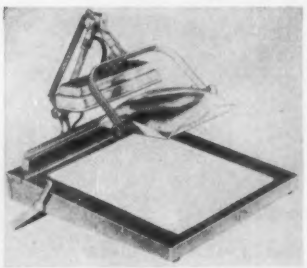
BETHLEHEM STEEL

BETHLEHEM STEEL

Mack C95F pumper for City of Lapeer, Mich.

Circle 592 on Page 19

NEED
GEARS?
Eliminate "high-cost specials"
by standardizing on
AMERICAN STOCK GEARS
Investigate and you'll probably find that instead of having to go to the added time and expense of ordering special gears, that your needs can be filled from the American line.
American is a 'complete' stock gear line. Manufactured by Perfection – a veteran of over 30 years in the gear business – these gears are made to the most precise standards, from the highest quality materials. This popular line includes brass, bronze, steel, semi-steel, cast iron, and non-metallic gears in a range of 48 to 3 diametral pitch.
You'll save time and money . . . save on inventory . . . simplify purchasing and have less lost production time by procuring your stock gear needs from your nearby distributor of American Stock Gears.
Ask for FREE copy of American Stock Gear Catalog No. 360 containing detailed information and engineering data.
AMERICAN STOCK GEAR division
Perfection Gear Co., Harvey, Illinois



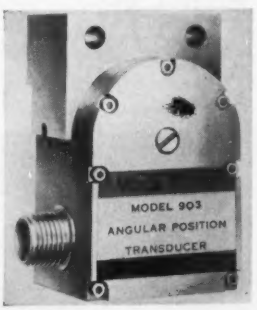
disc joints. Table also can be adjusted to lie flat or slant. Magnification has good resolution and high visual acuity. Viewer is supplied without lamps in handsome silver-gray finish. **Fostoria Corp.**, Dept. 32, Fostoria, Ohio.

Circle 779 on Page 19

Angular Position Transducer

measures small angles

Model 903 angular position transducer is sensitive to a rotation of 0.012 deg and has a range of ±3 to ±5 deg. Magnified input of a small angular movement actuates a wiper which moves across a precision potentiometer, producing a high-level dc output that can normally be used without amplification. Unit is completely sealed for high reliability during severe environmental conditions. Weighing 11 oz, unit



can be used in applications where space is at a premium. **Bourns Inc.**, 6135 Magnolia Ave., Riverside, Calif.

Circle 780 on Page 19

Transistorized Power Supply

has instantaneous overload protection

PS202MB twin power supply incorporates instantaneous electronic lock-out with automatic reset. Damage due to temporary over-

Alcoa puts the metal where you want it

How BIG an impact have you seen lately? Alcoa can now make them up to 12 in. in diameter and 60 in. long.

When Alcoa's new 2,500-ton press hits an aluminum alloy slug, a giant impact is formed with the combined strength of an extrusion and forging.

Like their small brothers, these big new impacts can save you money. They are produced in one fast operation. There's no parting line to be ground. No scale to be removed. No draft to be cut off. Impacts have forged bases and extruded sections. Multiple parts can often be combined into one integral impact eliminating welded or mechanical joints. Machining is reduced, and excessive material waste is eliminated.

You can get these big new Alcoa® Impacts in many alloys with tensile strengths up to 75,000 psi. Also made from aluminum powder metallurgy alloys which provide excellent properties at elevated temperatures.

Alcoa Impacts are unfailingly sound. They have smooth, corrosion-resistant surfaces. You can have them in plain or complex shapes with design features combining those of forgings and extrusions—flanges, steps, multiple walls, bosses, ribs.

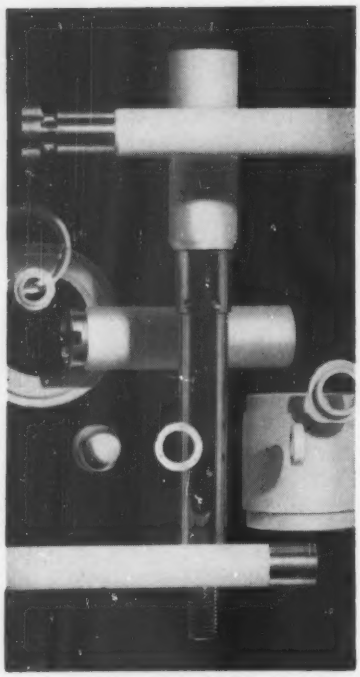
In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where you want it. A call to Alcoa can mean ingenious design solutions. Start now; write for *Metal in Motion*, Alcoa's new 34-page brochure on impacts. Aluminum Company of America, 905-F Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

Alcoa puts the metal where you want it . . . in impacts, castings, forgings, extrusions and screw machine parts.

Circle 594 on Page 19



Coors

Alumina Ceramics Replace Expensive Metals for Vital Pump Parts

The destructive twins—corrosion and abrasion—have led pump designers to use Coors High Strength Alumina Ceramics for the vital parts of pumps, such as plungers, cylinder liners, seal faces in mechanical shaft seals, shaft protection sleeves, and ball check valves.

Perhaps your abrasive and corrosive problems can be solved economically with Coors Ceramics. We shall be glad to help you—just write us at Golden or contact one of our regional sales managers.

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Central.....Donald Dobbins
GL 4-9638—Canton, Ohio
East Coast.....John J. McManus
MA 7-3996—Manhasset, N.Y.
New England.....Warren G. McDonald
FR 4-0663—Schenectady, N. Y.
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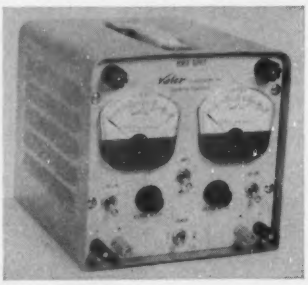
Circle 595 on Page 19

loads is eliminated by variable current limiting which prevents power supply from delivering in excess of any preset power level. Damage due to short circuits is eliminated by instantaneous electronic shut-off which automatically resets after short is removed. Fast transient



response, high reliability, low ripple, excellent regulation, and high stability are other features. Unit has two outputs, each 6-30 v dc at 0.5 amp; input is 105-125 v, 60-400 cps. **Valor Instruments Inc.**, 13214 Crenshaw Blvd., Gardena, Calif.

Circle 781 on Page 19

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are cooled with liquid CO_2

Series HL Geco test chambers, operating from —100 to +600 F, are cooled with liquid CO_2. Rapid pulldown enables shock testing. Four sizes from 2 to 8-cu ft working capacity are available. Chambers are bench models, fully sealed against moisture and equipped with silicone door gaskets. High-volume forced-air circulation insures accu-

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Circle 782 on Page 19

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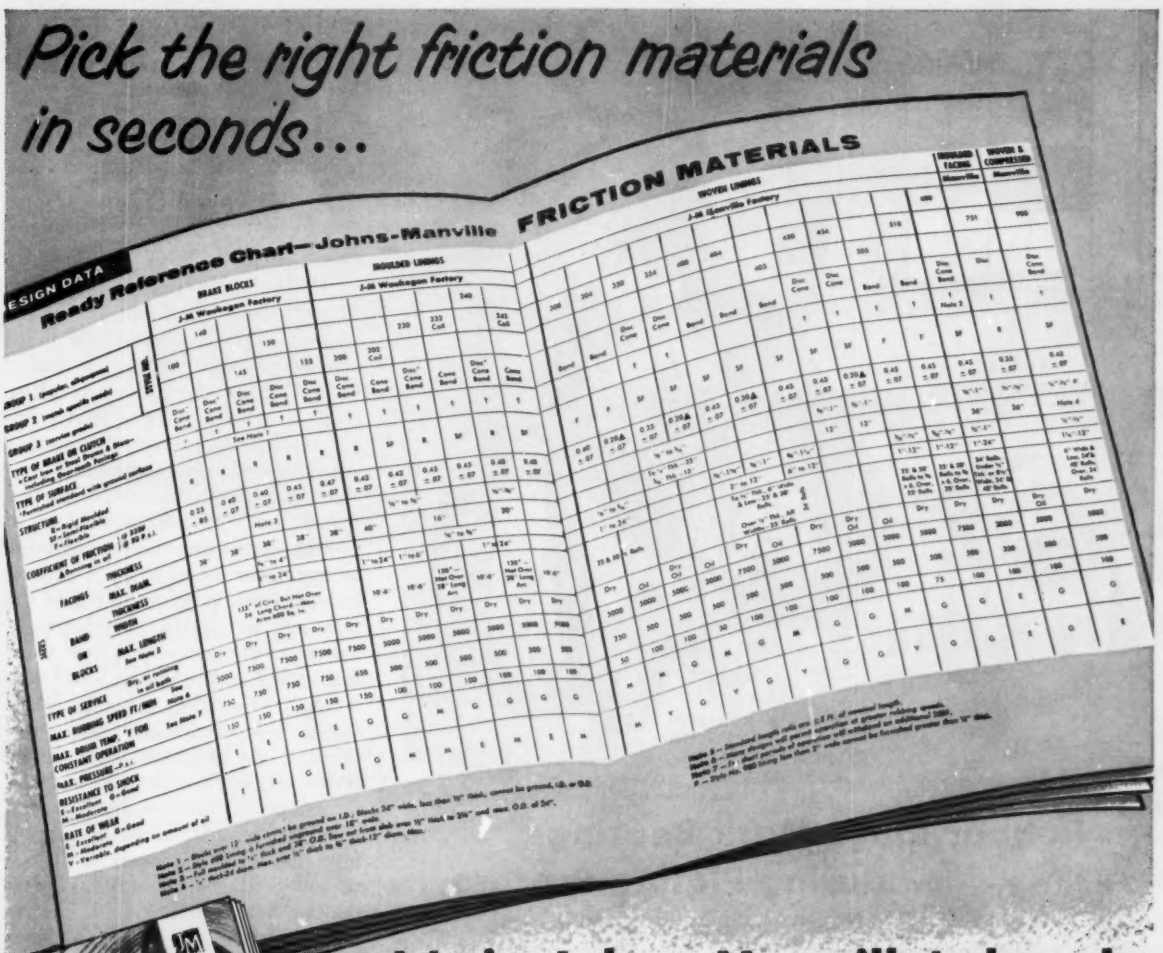

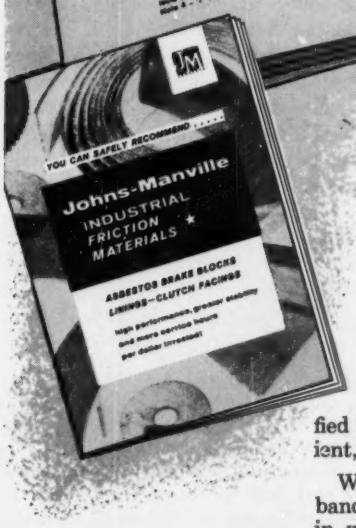

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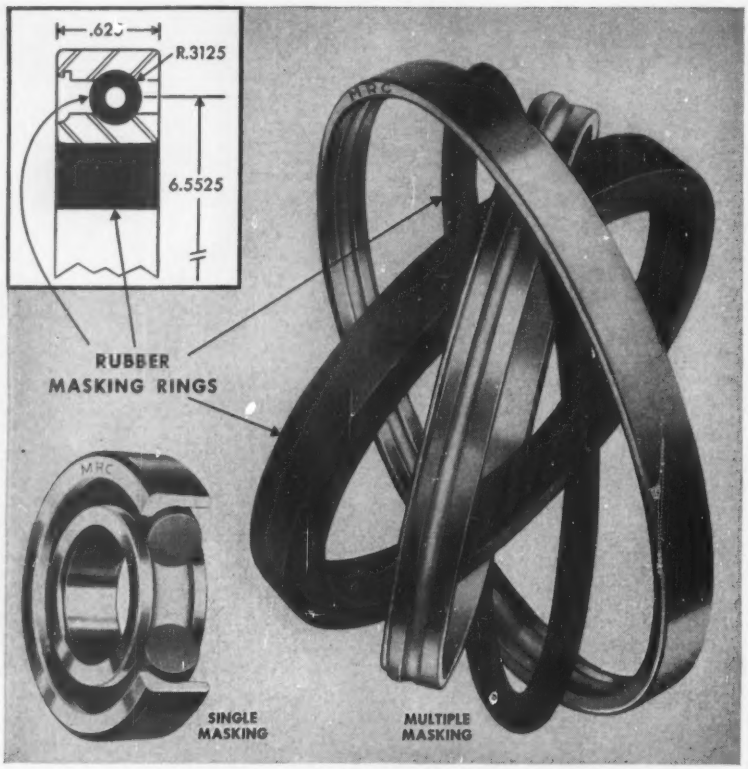

Photos courtesy Marlin-Rockwell Corp., Jamestown, N. Y.

Rubber Rings Mask Bearings during Plating Process

Here's a new way to mask out plating on bearing race grooves without tedious hand-labor. Regardless of bearing size, rubber rings are fitted precisely into ball grooves and inner ring bore so that plating can't sneak under the rubber even in torturous electroplating baths. Clean division lines always result. Inner ring and outer ring are held together so both can be plated simultaneously. This saves one complete plating cycle. And, this fast assembly prepares bearings for plating in seconds—eliminates costly hand-painting with unreliable stop-off lacquer.

These rubber rings are the result of Marlin-Rockwell Corporation (Jamestown, New York) consulting Continental to solve an important masking problem. Creative engineering successfully developed these extruded and spliced, or molded rubber rings which increased production 2000%—20 times faster than hand-painting. What's more, the special rubber compound withstands repeated baths in blistering acids and caustics without affecting precise dimensions, elasticity or resilience.

This rubber ring technique is typical of the thinking and ingenuity behind rubber parts by Continental. It also represents the economy and better end results accomplished by consulting a rubber specialist *during the planning stage* of a product. If you need help like this, call or write Continental —rubber specialists since 1903.

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In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

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Professional Viewpoints

. . . qualified to design . . .

To the Editor:

"Professional Viewpoints" in the May 12 issue prompted me to express my opinions, which are based on ten years' experience in design work. I have served in every phase of machine design from junior engineer through design engineer; I am now a consulting engineer.

Despite all the discussions I read, I feel that the major problem in finding competent design engineers is that there seems to be a general industry-wide program to regard the man on the board as inferior in stature to the man with a desk. Consequently the man on the board who is good, is forced to trade his board for a desk. Some companies will prevent an engineer from doing board work. Designers are really draftsmen in these companies and they are treated as being subprofessional. Junior engineers hardly out of college direct the efforts of men on the board, telling them how to design various mechanisms. Since the junior engineer doesn't know how to design, and since competent designers (under these adverse conditions) are rare, the result is unnecessary cost in dollars and time.

I enjoy design work, but I doubt that I will ever be a designer again. This is a result of having gained status in the profession.

—Meyer I. Mazon, P. E.
Cincinnati, Ohio

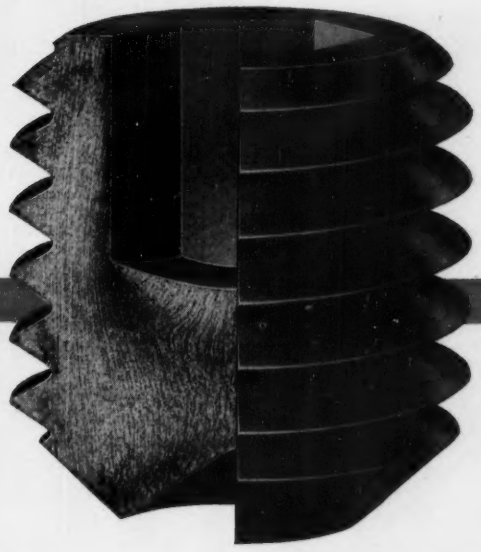
. . . the man nobody sees . . .

To the Editor:

Your editorial in the April 28 issue is real bait for comment. What is the difference between the doctor (M.D.) and the engineer (P.E.) in real life?

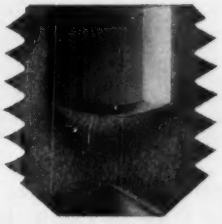
The doctor is subservient to few. He, like the pilot, calls the shots.

The engineer is a servant, not a director. He proposes stainless steel muffler cars (to keep the public happy) and the marketing people overrule him. (The muffler replacement business is a powerful influence.) He doesn't have the decision-



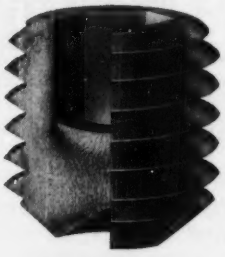
NO MYSTERY ABOUT H-K QUALITY!

Notice the smooth, flowing lines of the metal fibers that give strength to this set screw. Look at the clean, *forged* socket, scientifically proportioned in both depth and width for maximum strength. Notice the smooth, controlled contour of the precision forged cup. Features like these spell Quality . . . and H-K Quality saves time, trouble and money on the production line!



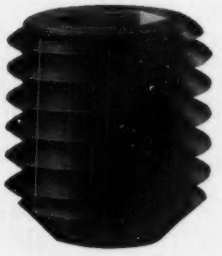
SCIENTIFICALLY FORGED SOCKETS

H-K's reinforced forged socket walls are always *uniformly accurate.* Keys fit snugly into the socket . . . get a firm and solid bite for positive, tighter wrenching action!



MICRO-CENTERED FORGED CUP POINTS

Holo-Krome's smooth, *perfectly-centered* cup points penetrate easily and deeply into the shaft . . . reduce friction . . . develop the ultimate in holding power!



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At every step along the way, start to finish—from metal analysis to the end product with its Unified Class 3A Fit—*Quality Control makes the difference* . . . guarantees the reliable performance of every H-K socket screw!

HOLO-KROME'S EXCLUSIVE FORGING METHODS AND REPUTATION FOR QUALITY ADD UP TO REAL SAVINGS ON THE PRODUCTION LINE!

Buying socket screws on price alone has frequently proved a costly and shattering experience for many manufacturers. Increased down-time, mounting rejects and failure in service not only wipe out so-called "savings" but affect business reputations as well!

That's why Holo-Krome's exclusive forging methods and reputation for quality always add up to *real* savings on your production line. And the reason you can always rely on H-K quality is because Holo-Krome has only one standard—*making the finest socket screws on the market!*

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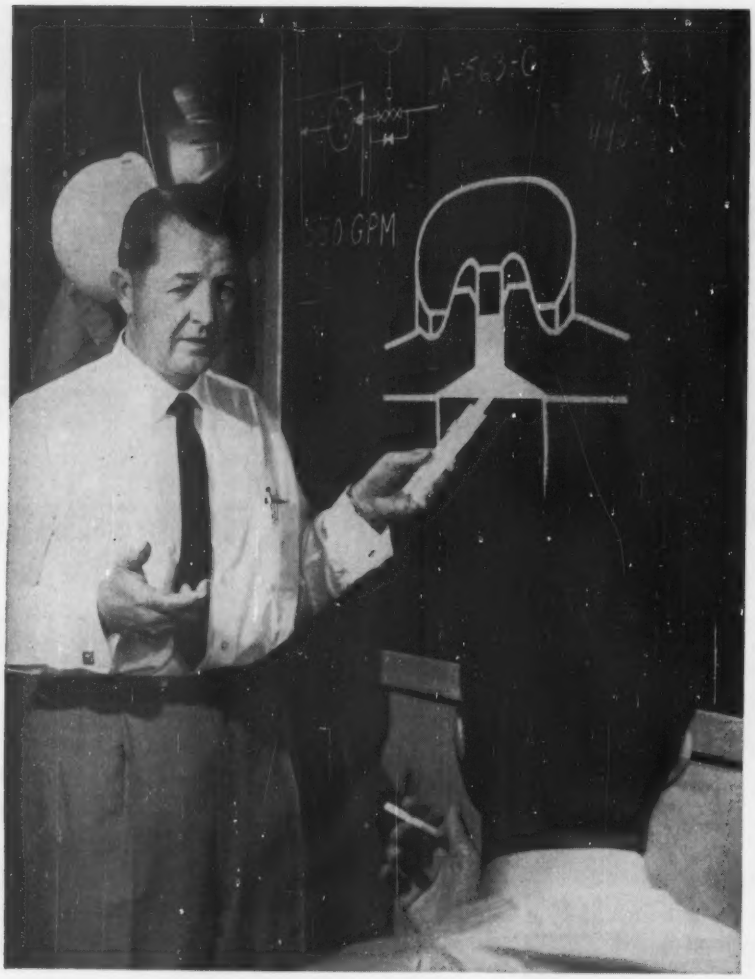

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making authority to say what kind of a muffler next year's car will have. He only proposes. He (in industry) can be overruled by marketing, the controller, sales, and others who obviously are not a part of engineering. This the public does not always realize, or understand.

The engineer is at fault in part if he is not strong enough in his sales ability, but he can hardly be compared in authority with the doctor, whose prestige comes in part from the fact that he deals with life and death in almost every move.

The engineer remains a servant, under the decision-making control of those who sell and those who provide and control the capital.

But let's make sure that he is a good salesman as well as a competent servant.

—W. E. MESH
Nichols, N. Y.

. . . rubber-covered cylinders . . .

To the Editor:

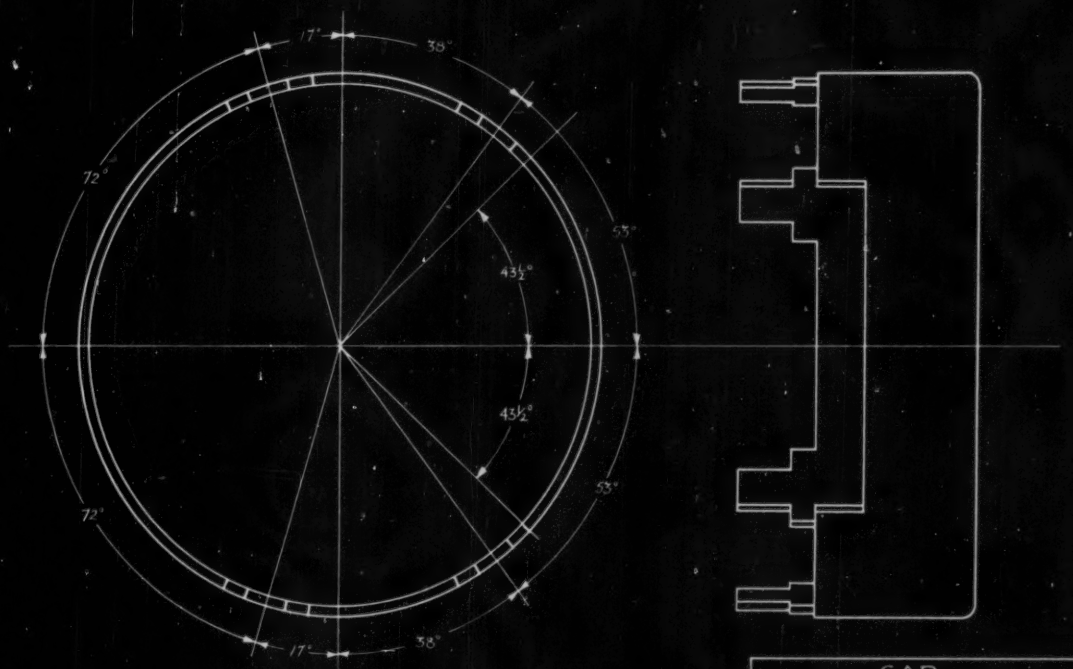
Your issue of April 30, 1959 (pp. 120-122) contained my article, "Rolling Radius of Rubber-Covered Cylinders." While doing further work, which produced the additional information reported here, I noticed that an error occurred in the article —for which I apologize.

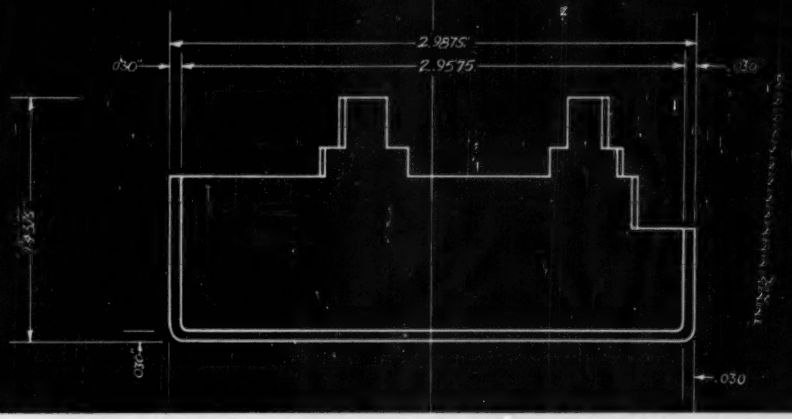
The slope in Fig. 3 should have been graded in steps of 1, from 0 to 5, and the slope in Fig. 4 should have been in steps of 0.4 from 0 to 2.0.

Here are some additional facts about the apparent phenomenon reported in that article:

The article showed that when cylinders, which have a solid rubber layer bonded to their surface, are pressed against all-metal cylinders of equal diameter, the rubber-covered cylinders always rotate slower than the metal ones, as long as the friction between the surfaces is large enough to overcome slippage, irrespective of whether the rubber-covered or metal cylinder is the driver.

It has been shown that the curves of speed difference in per cent as a function of radial rubber deformation tended to become straight lines. The radial thickness and axial length of the rubber have a considerable influence upon the slope of





CAP SPECIFICATIONS	
ANALYSIS	AISI – 1010
SIZE	4½" x .030"
GAUGE TOL.	± .0015"
WIDTH TOL.	± .005"
HARDNESS	ROCKWELL B-55 MAX
FINISH	#2
EDGE	#3 SLIT
COIL SIZE	225/300 LBS PER INCH WIDTH

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Of course, tolerance should be no tighter than necessary for the successful design of the finished part . . . or for efficient, trouble-free stamping. If the part cannot be fabricated with a minimum of production trouble, the tolerance is *not* tight enough . . . regardless of the design requirements of the finished part. In an intricate, high speed stamping operation, a variation of 0.003″ could easily result in a high percentage of rejects; could cause frequent down-time . . . constant tool adjustment; could create *needless* production problems.

Why not check your own stamping operation?

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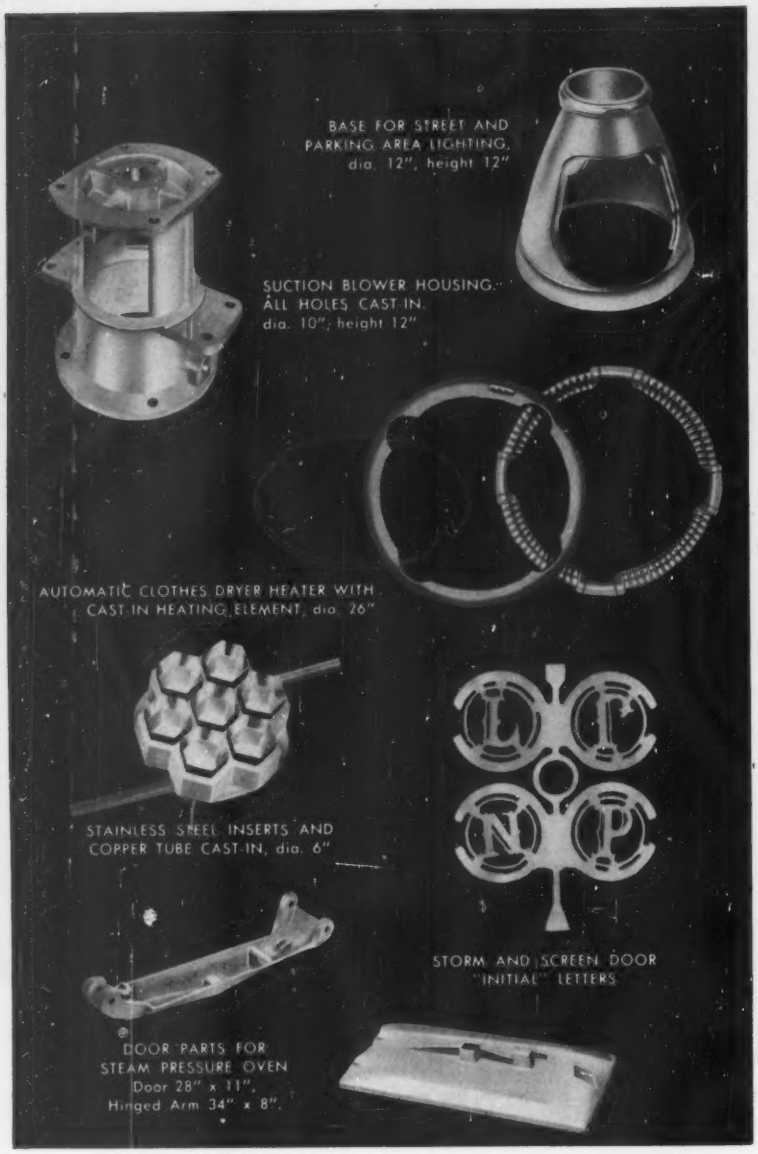
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the lines, whereas the hardness of the rubber did not noticeably affect the slope.

A further analysis of the results has now been carried out, including rubber-covered cylinders of 5, 7, and 8-in. outside diameters. This time the differential surface-speed ratio Δ_1 was plotted as a function of radial rubber strain ε for the case when the rubber-covered rollers were friction driven by the metal one, which rotated with a surface speed of approximately 75 feet per minute. These two terms are defined as follows: Differential surface-speed ratio Δ_1 is equal to the surface speed of the undeformed portion of the rubber-covered cylinder minus the surface speed of the metal cylinder divided by the surface speed of the metal cylinder. Radial rubber strain ε is equal to the radial rubber deformation divided by the undeformed rubber thickness.

If the radial strain was so large that no slippage occurred between the driving and driven surfaces, then, for the individual rollers, the curves followed an exponential law of the form,

$$\Delta_1 = -A(\varepsilon)^n + B \qquad (1)$$

where n varied between 0.9 and 2.3; the average for all curves: $n = 1.42$. Constants A and B appear to be due to side effects, friction, etc.

Superimposition of the curves for rollers whose axial length is at least four times as large as their radial rubber thickness resulted in curves which appear to approach a straight line of the form,

$$\Delta_1 = -0.49\,\varepsilon \qquad (2)$$

If the ratio of axial length to radial thickness is less than 4, the curve is flatter, probably due to the rubber bulging out at the ends.

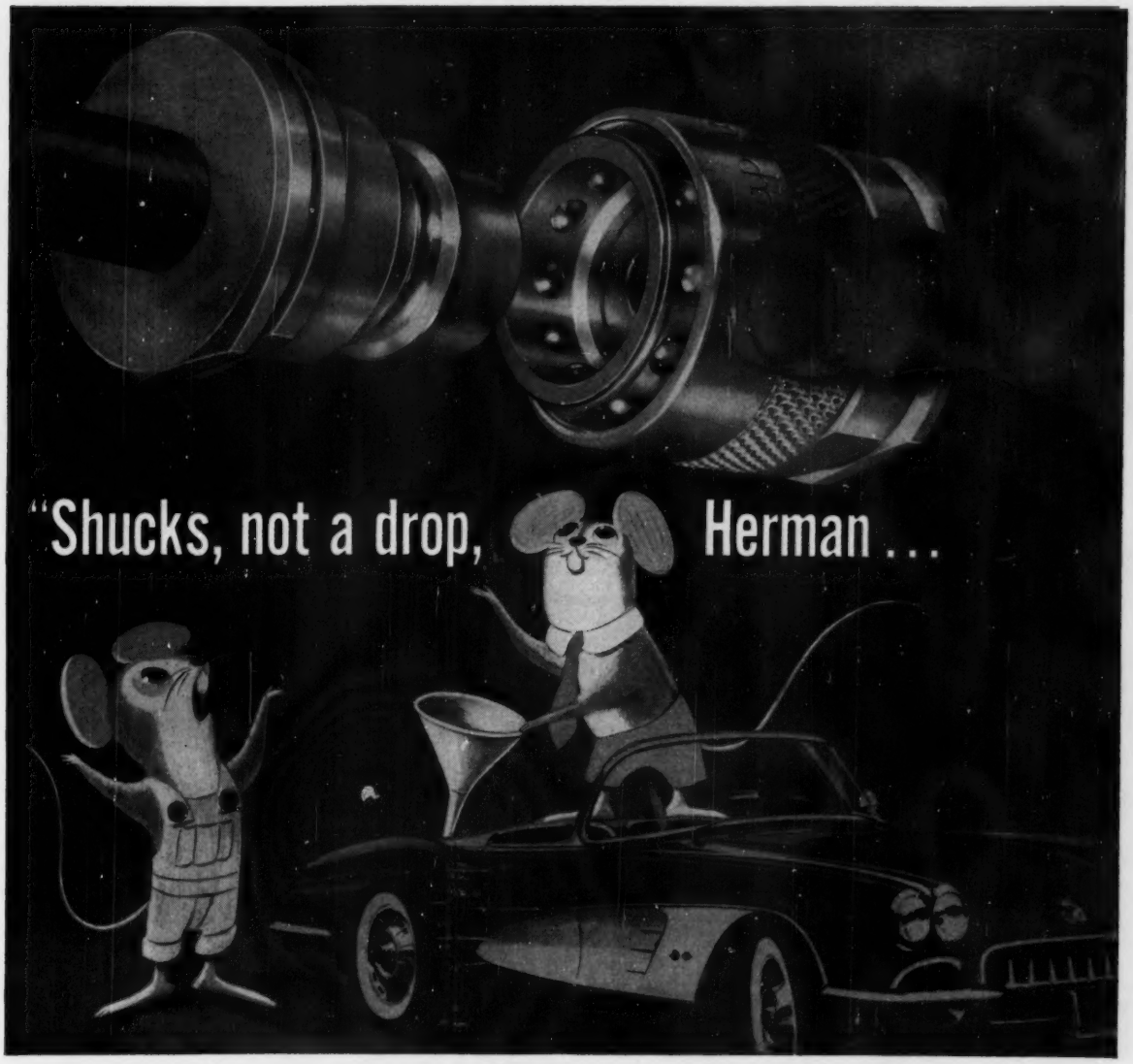
Equation 2 represents a limiting value within the range of the experiments. For values of ε smaller than 0.04 the actual curve seems to be flatter, possibly due to side effects, etc., and approaches the form,

$$\Delta_1 = -(\varepsilon)^{1.35} \qquad (3)$$

For design purposes, however, the equation of the straight line is a reasonable approximation.

—H. A. Borchardt
School of Mechanical Engineering
University of New South Wales
Broadway, N.S.W., Australia

Circle 602 on Page 19



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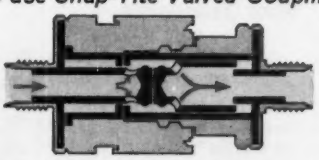

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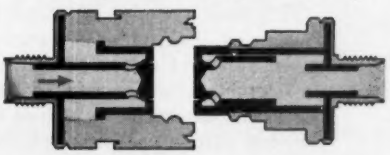

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A comprehensive survey of the unsaturated-polyester-resin industry is presented. Mechanical and physical properties, chemistry, curing mechanisms, manufacturing, reinforcing, casting, and coating are covered.

Mechanics of Materials. *By Archie Higdon, Edward H. Ohlsen, and William B. Stiles; 502 pages, 6¼ by 9¼ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$7.75 per copy postpaid.*

This book emphasizes the fundamental principles of mechanics of materials. Logical methods of procedure are developed and demonstrated.

Free-body diagrams and the equations of equilibrium are used to analyze the force system acting on a body. Also, geometry of the deformed body and the observed relations between stress and strain are employed in system analysis.

New Standards

ASTM Standards on Light Metals and Alloys—B7. *368 pages, 6 by 9 in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.50 per copy.*

This book contains 57 standards concerning aluminum and magnesium metals and alloys. Fifteen of the standards are revised or have had their status changed since the previous edition. A new specification for aluminum-coated steel wire for electrical transmission purposes, and a new method of test for elec-

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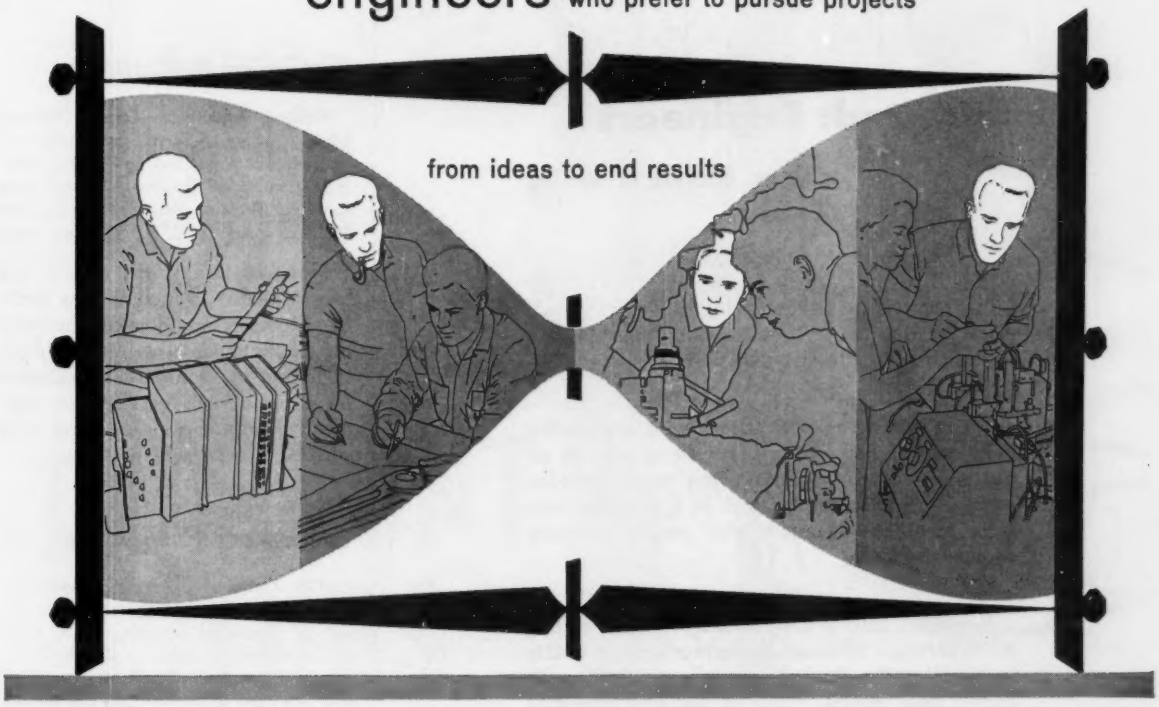

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trical conductivity using eddy-current procedures are included.

Association Publications

Welding Handbook—Fourth Edition, Section Three. *Edited by Arthur L. Phillips; 512 pages, 6¼ by 9¼ in., clothbound; published by and available from American Welding Society, 33 West 39th St., New York 18, N. Y.; $9.00 per copy.*

Scope of this fourth edition has been widened to include new welding processes and joining methods. Forge welding, thermit welding, soldering, plastics welding, adhesive bonding, oxygen cutting, arc cutting, ultrasonic welding, and stud welding are covered.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161129. Steady State Undamped Vibrations of a Class of Nonlinear Discrete Systems. By P. R. Sethna, B. E. Fristedt, and V. G. Harvester, all from University of Minnesota; 37 pages, 8¼ by 10¾ in., paperbound, stapled; $1.00 per copy.

Steady-state vibrations of a class of nonlinear discrete systems with an arbitrary number of degrees of freedom are studied. Coordinates of the system are transformed to the principal co-ordinates corresponding to the linear part of the system and a perturbation scheme is used to obtain solutions.

PB 161291. Basic Research Resumes—A Survey of Basic Research Activities in the Air Research and Development Command. 342 pages, 8 by 10½ in., paperbound, stapled; $5.00 per copy.

This summary index describes 1400 research projects conducted at U. S. colleges and universities, industrial laboratories, government facilities, and private nonprofit research institutions. Technical program areas of propulsion, materials, electronics, aeromechanics, geophysics, and biosciences are covered.

NASA Technical Notes. Copies of publications listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TN D-256. Fatigue Damage During Complex Stress Histories. By H. W. Liu and H. T. Corten, University of Illinois; 56 pages, 7¾ by 10¼ in., paperbound, side-stapled; $1.50 per copy.

Relation between fatigue life and the relative number and amplitude of imposed cycles of stress was determined in wire specimens of 2024-T4 and 7075-T6 aluminum alloys, and hard-drawn steel. A two-parameter expression, involving the per cent of cycles at high stress and a stress interaction factor, was developed to determine fatigue life. The experimentally determined fatigue life proved the expression to be satisfactory.

TN D-259. Rolling-Contact Fatigue Life of a Crystallized Glass Ceramic. By T. L. Carter and E. V. Zaretsky, Lewis Research Center; 35 pages, 7¾ by 10¼ in., paperbound, side-stapled; $1.00 per copy.

Rolling-contact fatigue properties of a crystallized glass ceramic were investigated with a five-ball fatigue tester. Effects of contact-stress, contact angle, test lubricant, and test temperature up to 700 F are reported. This material may be useful in low-load, short-duration applications where an operating temperature above the limits of steels is the paramount design consideration.

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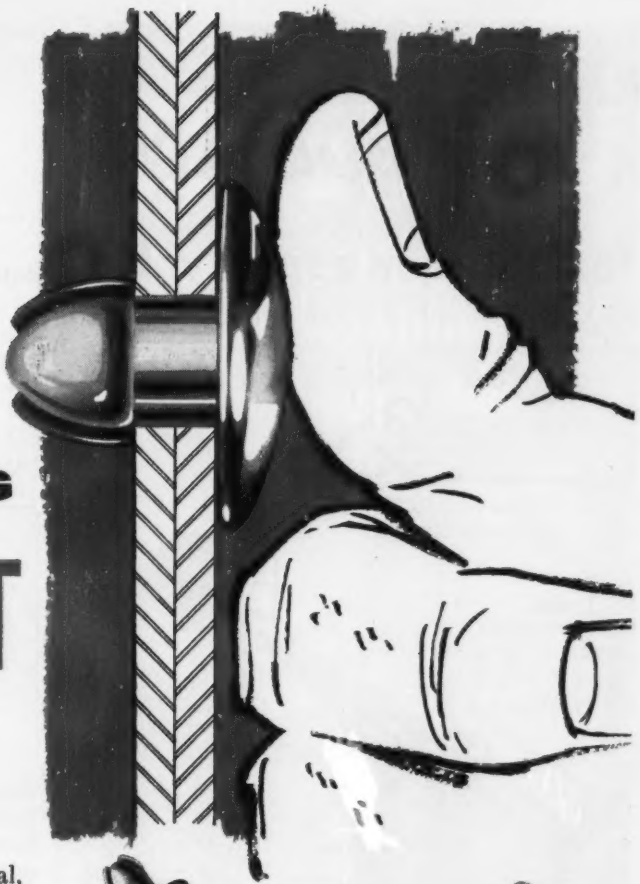

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Patents

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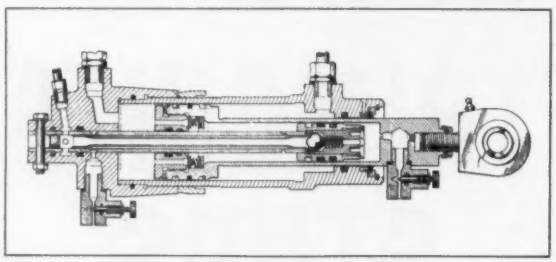
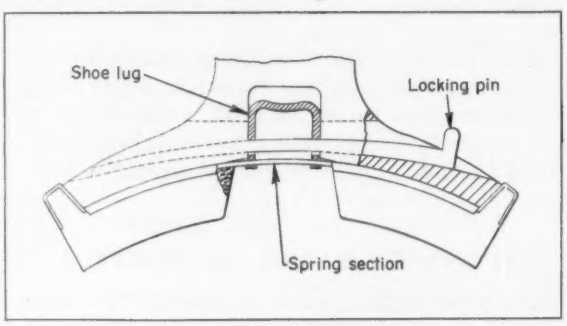


chambers. Each of these chambers is connected to high-pressure gas through a check valve. Gas in these chambers cushions the movement of the piston. The rate at which gas is metered from a chamber governs the speed of piston movement. *Patent* 2,932,281 *assigned to North American Aviation Inc., by Arthur Moskowitz.*

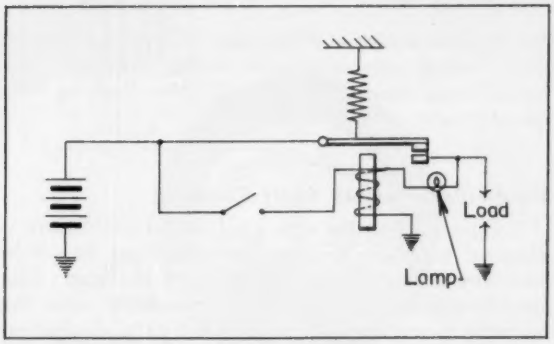
Flexible Brake Shoe Assembly



Leaf-spring section in backing plate of brake shoe maintains pressure not only between the backing plate and its radial support but also between the shoe key lug and its tapered locking pin. *Patent* 2,933,164 *assigned to Westinghouse Air Brake Co., Wilmerding, Pa. by Clarence R. Baechtel.*

Time-Delay Circuit Breaker

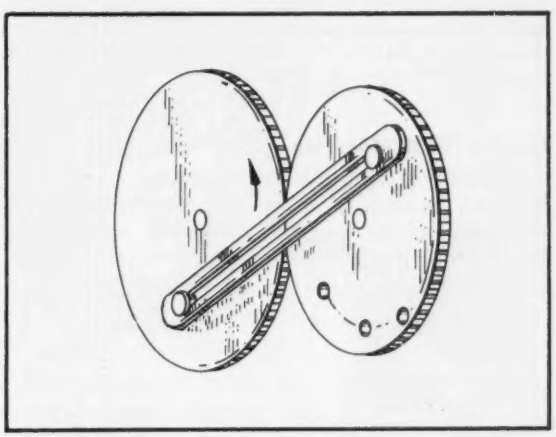
Delay of 1/10 to ¼ sec in breaking the switch contacts within a load circuit is provided by an incandescent lamp. Make and break operation of the load-switch



contacts is provided by a solenoid. When the control switch is closed, the lamp is de-energized and the solenoid coil is energized to close the load switch. When the control switch is opened, the coil remains energized momentarily by flow of current through the cold lamp. Increased resistance of the lamp through heating diminishes the current flow to the coil. When the pull of the coil on the load switch decreases sufficiently, a spring opens the switch contacts. *Patent* 2,932,774 *assigned to General Motors Corp., Detroit, by Lyman A. Rice.*

Four-Bar Limit-Stop Mechanism

A two-gear limit-stop mechanism uses a slotted, pin-mounted connecting rod to limit angle of rotation. Numbers of teeth on the gears govern the extent of



angular motion and must differ by at least one tooth. For any gear combination, adjustment is provided by varying radial position of a pin. *Patent* 2,928,516 *assigned to the United States of America by Edward A. Bennett.*

Moving-web tension regulator measures tension in a sheet or a strand at one point for control at another. The moving web passes over a series of rolls, one of which is supported at the ends by two cantilever strain members, which bend in response to changes in web tension. Each cantilever carries two strain-gage elements. Elements on corresponding faces of the two cantilever strain members are connected in series in

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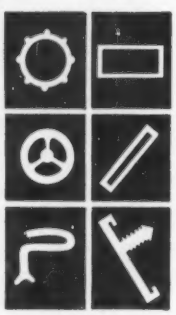

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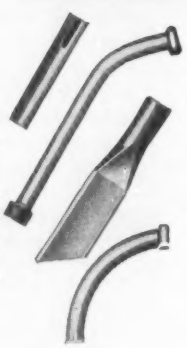

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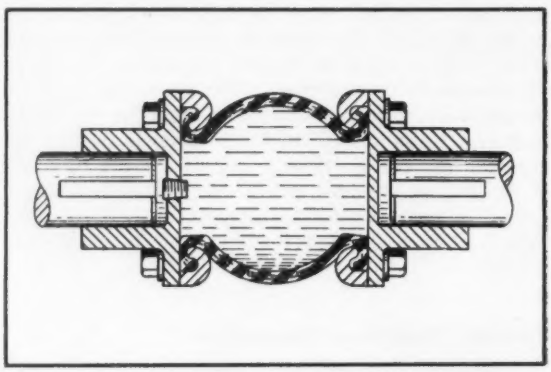
the opposite legs of a Wheatstone bridge, which transmits a signal representative of tension conditions. *Patent 2,931,962 assigned to Huck Co., New York, by William F. Huck.*

Fluid-Filled Flexible Shaft Coupling

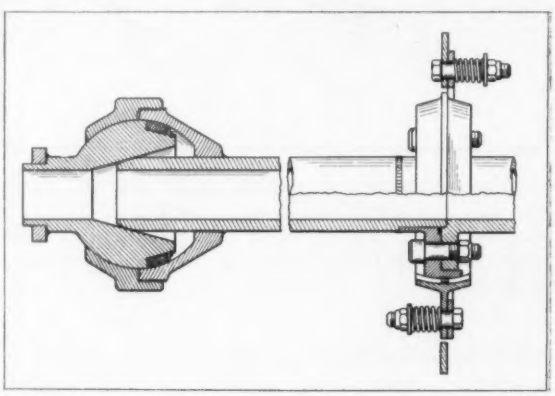
Torque transmission with a hollow flexible element is obtained when the flexible element is filled by a substantially incompressible fluid to resist buckling. The flexible element and its supporting medium allow the coupling to accommodate angular and parallel misalign-



ment as well as end play between connected shafts. Modifications of the basic design permit selective control of the degrees of freedom of the flexible element, one at a time. *Patent 2,929,231 assigned to the Firestone Tire & Rubber Co., Akron, Ohio, by Thomas A. Bank.*

Flexible Duct Mounting

Dimensional changes in liquid-carrying ducts caused by wide variation of temperature and pressures are accommodated by a spring mounting arrangement. Bolted to the duct, three ring-type parts are so shaped



that expansion of the duct compresses two springs. Similarly, contraction of the duct compresses two different springs. In either case, little axial force is transferred to the mounting base. *Patent 2,931,672 assigned to the United States of America by George W. Merritt and Joseph J. Yuhas.*

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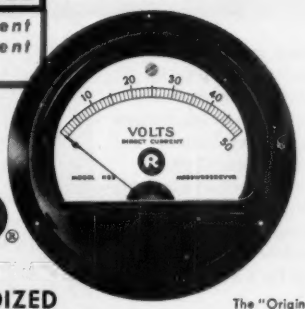

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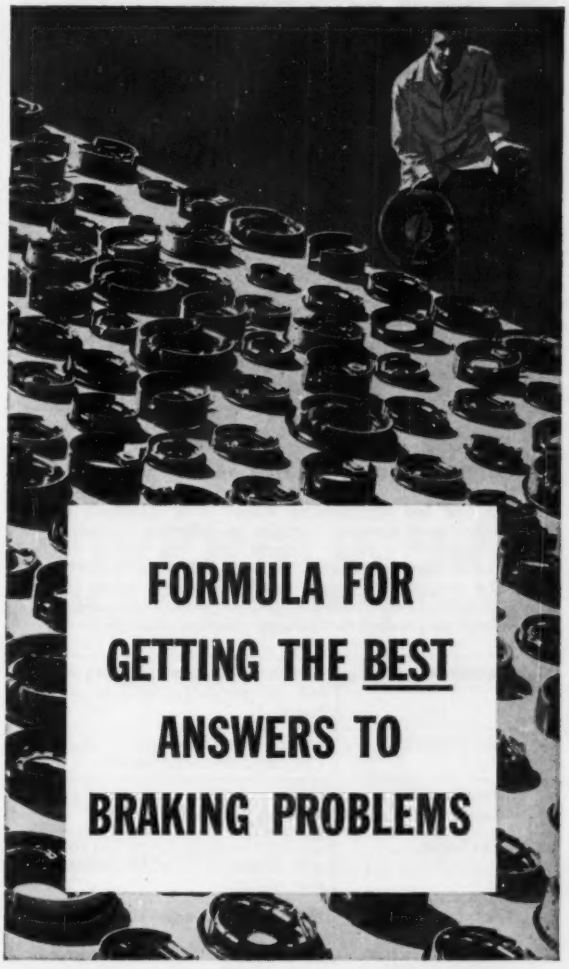

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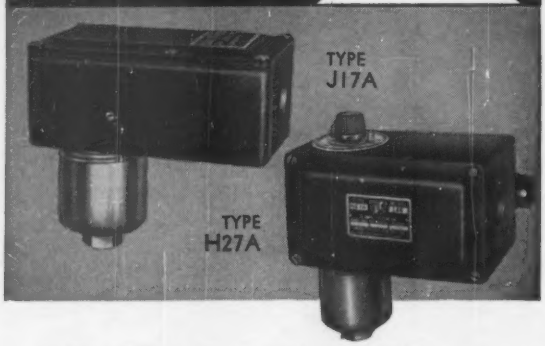
J17A | H27A



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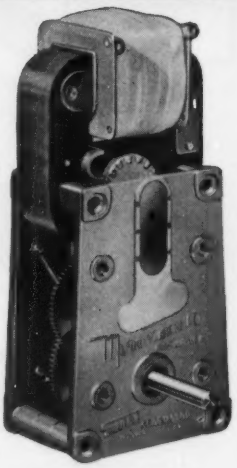

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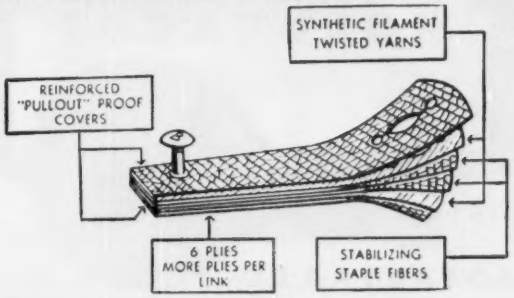
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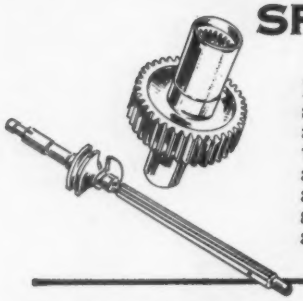

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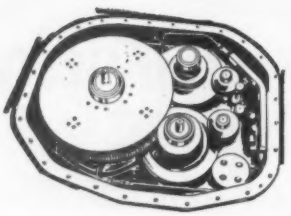

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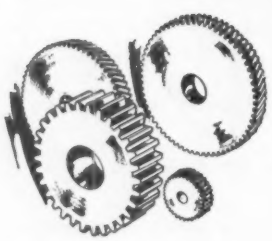

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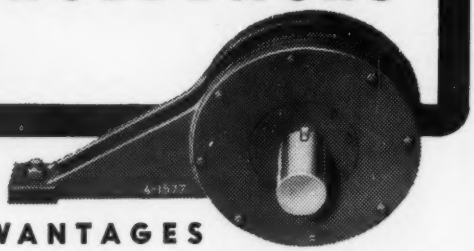

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- Prevents disastrous reversal of heavily loaded belts during power failures.
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- 2 7/16" to 12" bore sizes available.
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ENGINEERED BULK HANDLING SYSTEMS

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for Air or Oil Hydraulic Service, 30 to 150 p.s.i.

- ★ ULTRA COMPACT...only 4-9/16" long, 3-5/16" high, 1-3/4" wide overall!
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Circle 618 on Page 19

Circle 620 on Page 19

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This free manual shows all sizes and styles of loop clamps, bonding clamps, multiple clamps, center clamps, wire harness clamps, wave-guide clamps—plus blocks, brackets, busbars, line supports, and related items.

Sizes from ⅛" to 6" diameter in 16ths for bolt mountings from #4 to ⅜". Available in aluminum, steel, and stainless. All manner of high and low temperature insulation materials.

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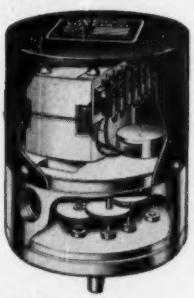
AUTOMATIC and REMOTE POSITIONING CONTROLS

Your present product, without redesign, can be controlled

BY JORDAN

20

SIZES AND TYPES OF ELECTRIC ACTUATORS both rotary and linear for valves, feeders, variable speed drives, pumps, reactors, storage conveyors. Program and position controls for a wide variety of industrial equipment.



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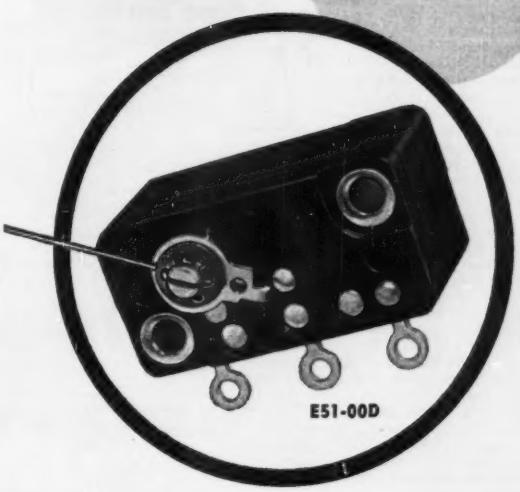
New FEATHER TOUCH SNAP ACTION COIN SWITCH



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Extremely low operating force and precise tolerances provide positive electrical control for pressure indicators, sensing timers or relays, office machines and vending machines. Operating force can be varied by length of actuator wire.

Your switching problems may find solution from over 8,000 Cherry switch variations. Write for complete literature today!

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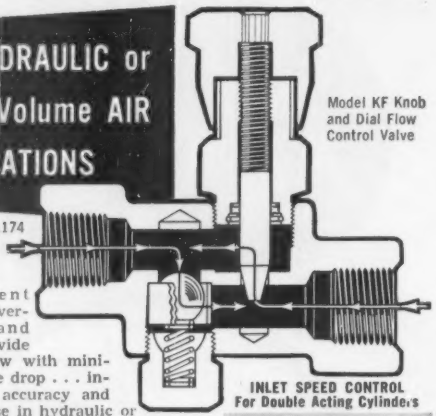
AUTO-PONENT VALVES | FLOW CONTROL, NEEDLE, CHECK

For HYDRAULIC or Large Volume AIR APPLICATIONS

Patent #2,841,174



Model KF Knob and Dial Flow Control Valve

Auto-Ponent Valves with oversize ports and passages provide maximum flow with minimum pressure drop . . . insure greater accuracy and quick response in hydraulic or large volume air cylinder control. Self-aligning needle has unique Quad-Ring gland seal located at pressure port to seal off threads in needle housing, allowing needle to turn easily under maximum pressures. Gland structure and location also prevents air or dirt trapping in the housing. Flow Control and Check Valves have sensitive, chatterless ball check. Patented design insures rapid ball movement to open or close fully at low differentials. Made in 5 female Dryseal pipe sizes from ⅛" to ¾" inclusive. 3 Models: Standard, Knob and Dial, and Panel Mounting. Valve bodies are forged aluminum (3000 psi), steel or stainless steel (5000 psi). All internal parts are Stainless. Typical applications shown at right. Write for catalog AP59.

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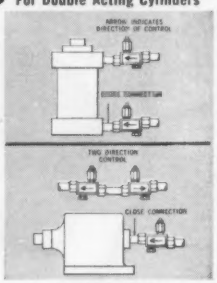
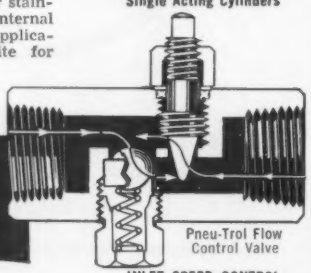
For Double Acting Cylinders



SPEED CONTROL
Single Acting Cylinders

For AIR APPLICATIONS

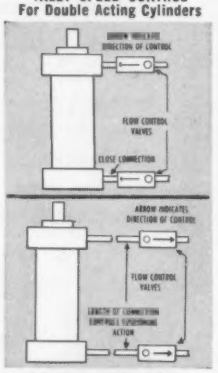
Patent #2,811,174



Pneu-Trol Flow Control Valve

INLET SPEED CONTROL
For Double Acting Cylinders

Pneu-Trol Flow Control, Needle, and Check Valves are widely used for air or small volume hydraulic cylinder control. Extremely compact design permits consolidated piping arrangements. Long tapered needle provides very sensitive and accurate air or oil flow control. Sensitive floating ball check opens or closes fully at slightest differentials. Valve bodies are machined from solid hexagon bars of aluminum or brass (2000 psi) steel and stainless steel (5000 psi). All internal parts are stainless steel. Made in 5 female Dryseal female pipe sizes: ⅛" to ¾" inclusive. Typical applications of Pneu-Trol Flow Control Valves are shown at right. Write for Pneu-Trol Valve Catalog No. 22.



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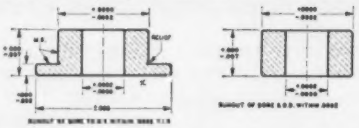

WRITE, PHONE for catalog-engineering data on standard and special sizes.
Northfield Precision Instrument Corp., Island Park, L. I., N. Y. GEneral 1-1112

NORTHFIELD
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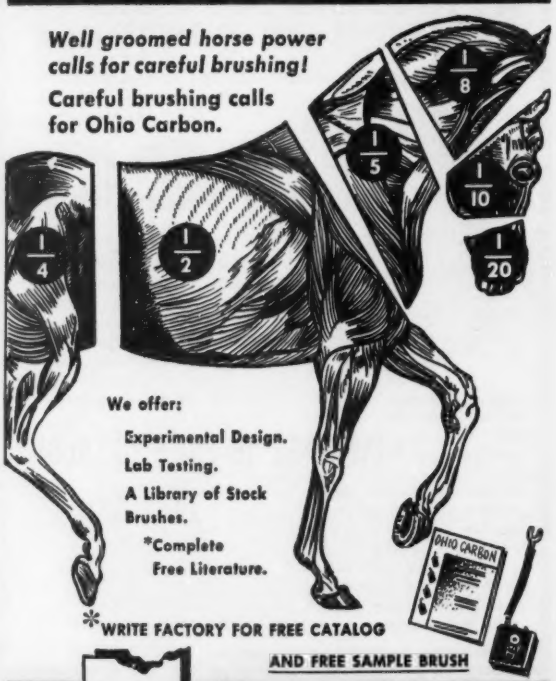

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Circle 626 on Page 19

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15 circuit unit shown

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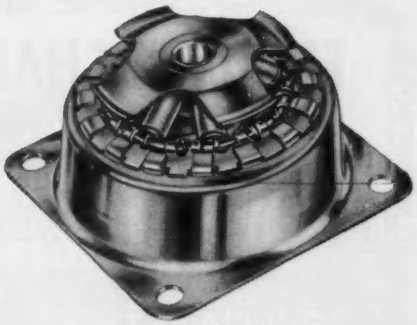

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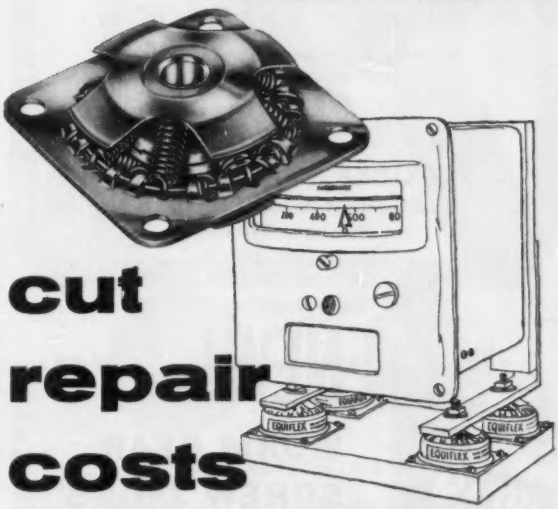
all-metal **VIBRATION ISOLATORS**



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Actual Equiflex installations have saved as much as twice their own costs in a single year by reducing repair costs for instrumentation and control equipment.

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The UCINITE COMPANY

Division of United-Carr Fastener Corp.,
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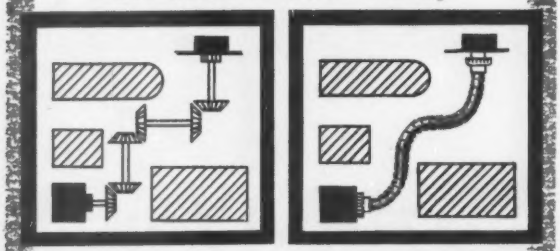
Cut Corners—Save Money



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For...

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Conveyor Adjustments
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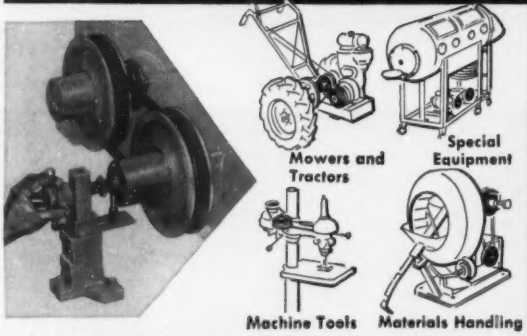
Control Speeds on Variety of Machines



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time/delay/relays

These relays have recently been re-designed—improved in performance *and* appearance. So you'll want up-to-date specs.

This free folder gives complete details on all models. In it you'll find operating specs, timing ranges, contact capacities, dimensions, diagrams of contact and terminal arrangements, and data on mounting and installation accessories.

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ELASTIC STOP NUT CORPORATION OF AMERICA

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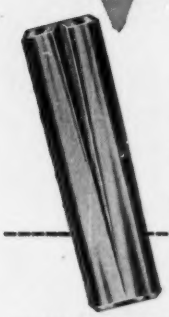
Circle 634 on Page 19

have you checked

DRIV-LOK PIN *advantages?*



1. **Positive anchoring . . . once in they *stay in* . . . yet they're re-usable**
2. **Stronger, safer, solid body**
3. **Quick installation . . . Lower Costs**

DRIV-LOK Pins are effecting great economies and product improvement in applications of every type. Easy to install—just drill the hole and press or drive them in. The job is done—no reaming, no expensive hole preparation. Available in carbon steel in 8 standard types; also a wide variety of special materials. Write us, describing your fastening requirements. Catalog and samples sent without obligation.

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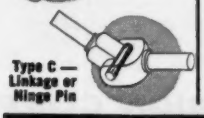

Type C—Linkage or Hinge Pin

DRIV-LOK SALES CORPORATION

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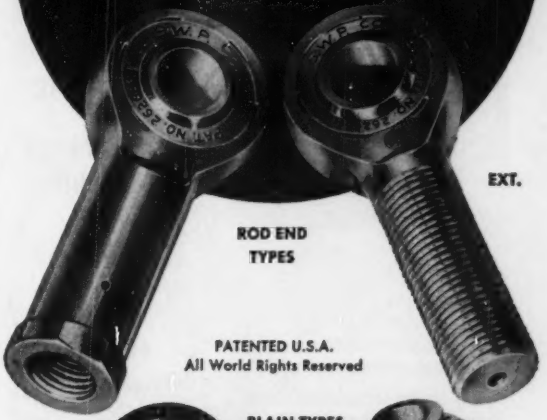
"Monoball"®

SELF-ALIGNING BEARINGS



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ROD END TYPES

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PLAIN TYPES

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
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KEBP2HB-5

- Long life
- Easy wiring
- Wide-range adjustability

Check these five advantages.

1. Nylon bearing in roller rotating on steel stud, needs no lubrication, gives years of service.
2. Nylon insert in plunger cuts friction, minimizes side thrust, decreases wear on plunger bearing.
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4. Roller-arm position is infinitely adjustable through a full 240 degrees of arc.
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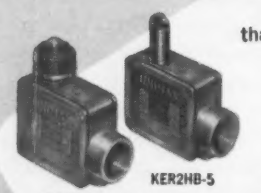
And, as in all UNIMAX enclosed switches, wiring is easy because

- all connections are made with standard basic switch outside metal case
- switch is removable from either side of case
- metal case can be mounted from either side.

Write for catalog that gives details of the entire K series.



KEB2HB-5 KER2HB-5

ELECTRICAL RATINGS:
20 amperes
125/250/480 v. a-c

UNIMAX SWITCH
Division, The W. L. Maxson Corporation
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BOWSER

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TELEFLOW INDICATOR

Mechanical and electrical flow indicators; single and double-window flow sights; window flow indicators; and a full line of sight-feed oilers for O.E.M., in-plant and mill or machine installations.

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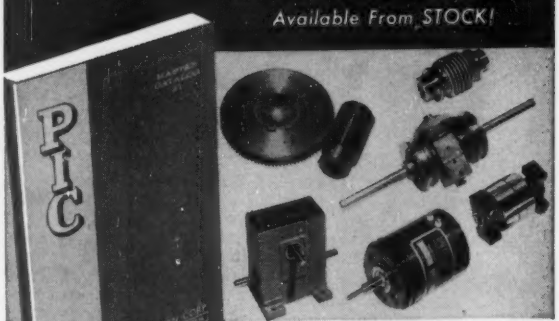

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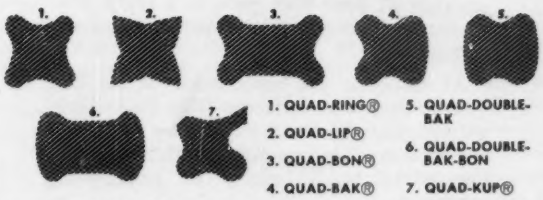
SPECIAL QUAD-RING® DESIGNS

MINNESOTA MR RUBBER



1. QUAD-RING®
2. QUAD-LIP®
3. QUAD-BON®
4. QUAD-BAK®
5. QUAD-DOUBLE-BAK
6. QUAD-DOUBLE-BAK-BON
7. QUAD-KUP®

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QUAD-RING—An exclusive development of Minnesota Rubber to give outstanding service in a wide range of dynamic and static sealing applications. **QUAD-LIP**—Developed for applications which require zero leakage at very low pressure differentials with minimum mechanical interference. **QUAD-BON**—Provides maximum resistance to spiraling in the smallest space possible while maintaining the sealing characteristics of the basic QUAD-RING. **QUAD-BAK**—Designed to eliminate damage to packing when subjected to extreme extrusion in one direction only. **QUAD-DOUBLE-BAK**—A double acting packing for maximum resistance to extrusion while maintaining two effective sealing lips. **QUAD-DOUBLE-BAK-BON**—Provides maximum resistance to both spiraling and extrusion in a double acting installation. **QUAD-KUP**—A unidirectional seal used where low friction is desirable but tolerances require a relatively large rubber-to-metal interference to take up for runout. These special cross sections of the basic QUAD-RING design are just a few of the modifications possible to give complete versatility for any sealing application.

Manufactured under U.S. patents RE 24332 and 2,873,132, other patents pend.

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8 Pages packed with data . . . dimensioned drawings . . . torques . . . weights . . . selection information. Request Bulletin 605

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THE COMPLETE LINE OF CLUTCHES . . . BRAKES . . . CLUTCH-BRAKES

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DIALCO® OIL TIGHT INDICATOR LIGHTS

for heavy duty industrial applications

Mounts in 1" clearance hole
No. 104-3502-XP10-231

DISCS with **legends**, behind flat lenses, deliver specific messages.

NO OIL, WATER, DUST or FUMES CAN PENETRATE THE *Built in* BARRIERS

(Illust. approx. 60% actual size)

Mounts in 1" clearance hole
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Mount in 11/16" clearance hole

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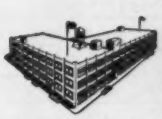

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BPA NEP

backtalk——

——Jolly Good Fellows

Congratulations are in order and are being exchanged by Colin Carmichael and Jesse Huckert, both of whom have been elected Fellows of the American Society of Mechanical Engineers. Jesse's elevation to this level of ASME was sponsored by the Production Engineering Division. He learned of the honor several

months ago and accepted it officially at the division's conference in May. Colin, serving as toastmaster at the spring meeting of the Cleveland Section of ASME, introduced the chairman of the Honors Committee and had hardly settled back in his chair again when he was called upon to accept his own honor.

A Fellow of ASME must have logged 25 years of active practice, ". . . must have made outstanding and recognized contributions to the advancement of the science of engineering or teaching of engineering . . ." and ". . . should be recognized as an outstanding authority in a particular field of engineering . . ." With such requirements it is no wonder that only 1 per cent of the membership ever gets to be Fellows. We are proud to have more than our share.

——In This Corner

No, we don't have a section of our office space roped off and labeled "The Editors' Corner" just to have a place where we can shake hands with each other; background of the picture of Colin and Jesse is MACHINE DESIGN's booth at the Design Engineering Show. We couldn't get these two busy Fellows together in Cleveland to take a picture, so we had to catch them at the show in New York. Jesse, who is chairman of ASME's Machine Design division, presided over the conference sessions; Colin was an "interested observer." We were all interested attendees of the show and were glad for the opportunity it afforded to meet and talk with the 20,000 of you who were also there.

——All About Articles

For our last October 15 issue, Colin Carmichael wrote an editorial encouraging the writing of articles; in this same issue your helpful Backtalk page offered two pamphlets to aid the neophyte author. In typical story-of-our-life fashion, we soon discovered that the supply of one of these pamphlets was not going to be enough to take care of the demand. Response was gratifying to the point of embarrassment, since we had to write back to many people and ask them please to be patient while we prepared a new edition.

We can now report that the new pamphlet, called *All About Articles* and combining the contents of the two former ones, has been mailed to all the patient readers who have been watching their mailboxes for them. Not only that, but we still have some copies left—a couple thousand of them. Anybody who wants one can get it free and IMMEDIATELY by writing to: Editorial Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

——More for Free

While the spirit of generosity is stirring within us, we would like to point out the availability of free reprints of MACHINE DESIGN articles. A fresh list of those currently available is in this issue, along with a convenient coupon for requesting copies. While you're back here, why not take a look at Page 278 to see if there's anything you can use.

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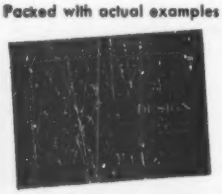

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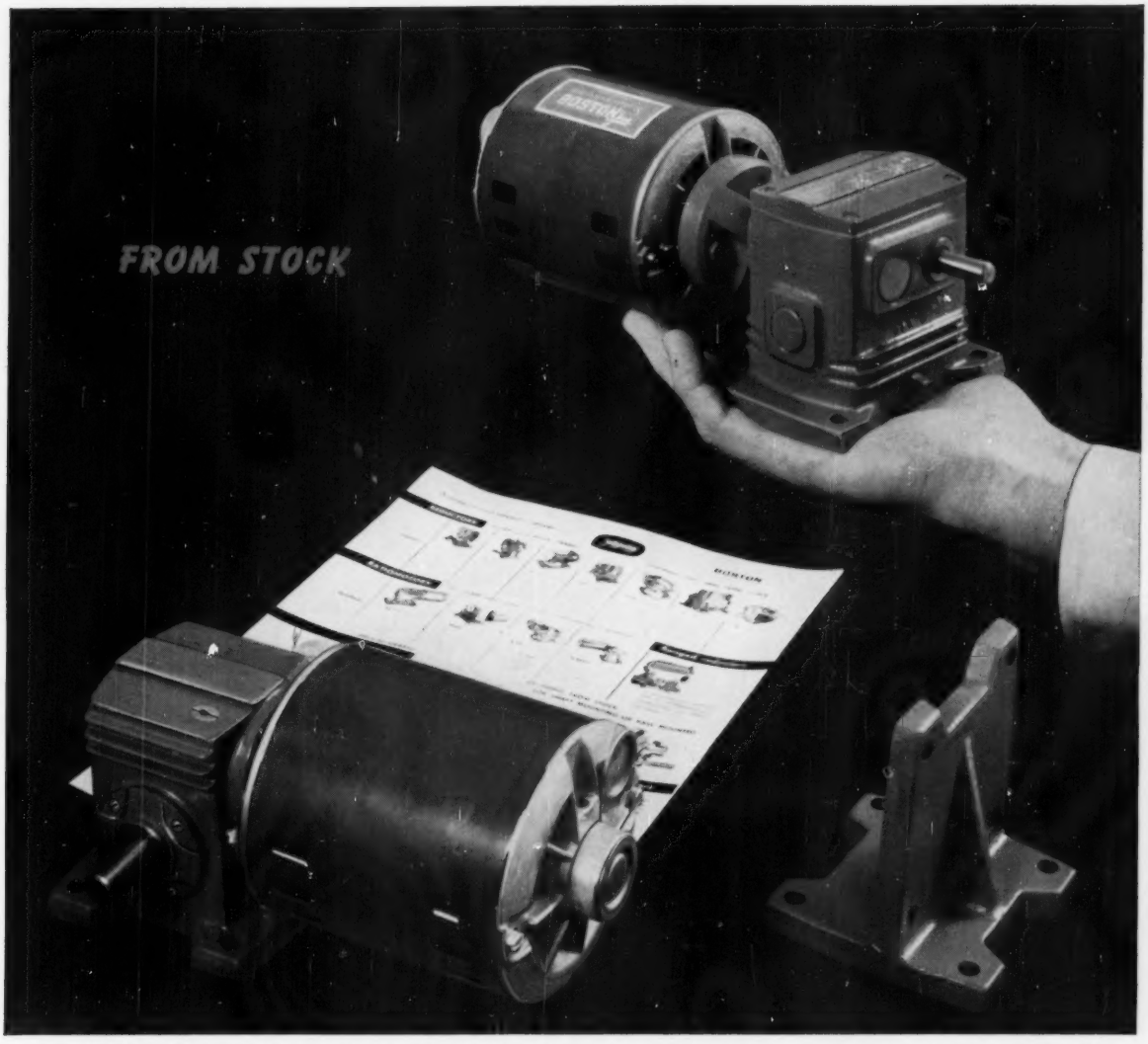

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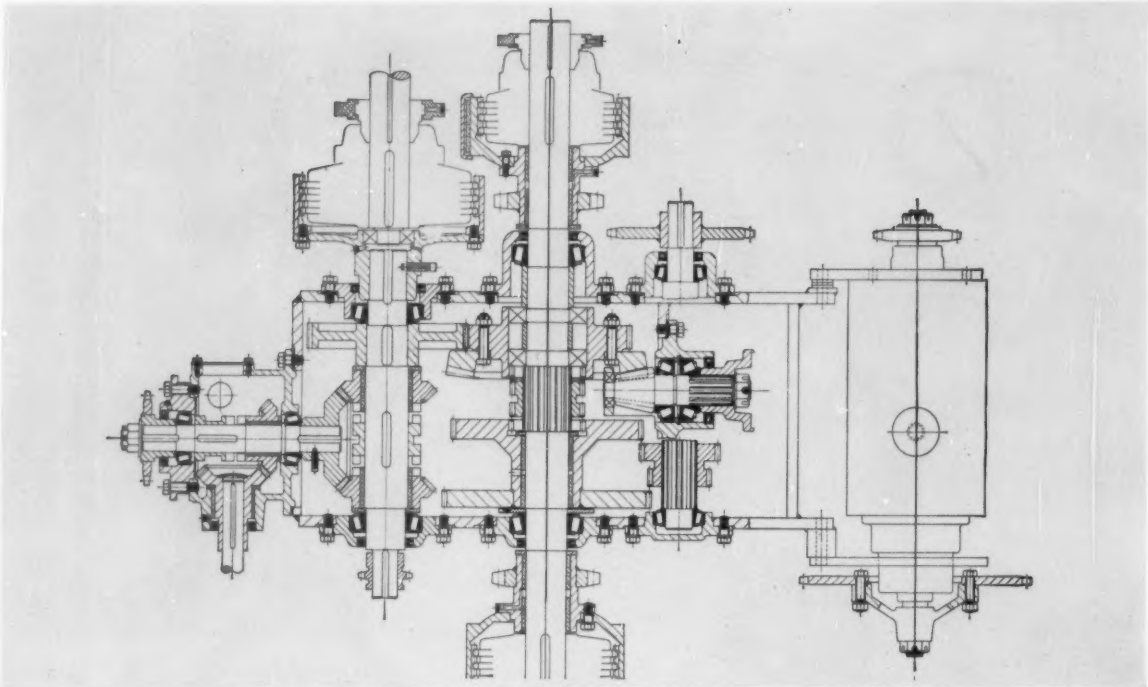
How Parsons mounts shafts to take heavy loads, keep Trenchliner digging



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